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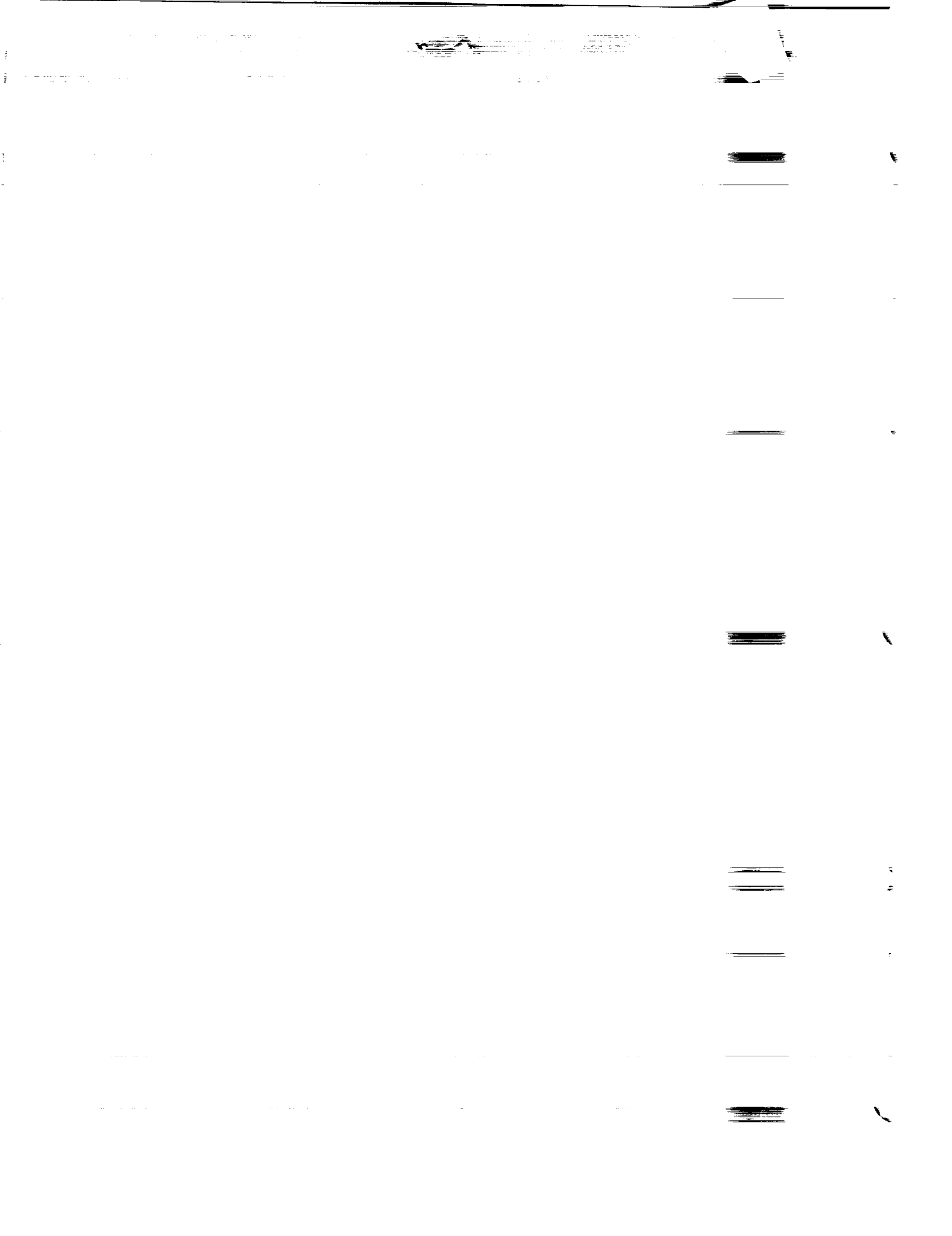
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FACILITIES MAINTENANCE HANDBOOK



National Aeronautics and
Space Administration

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PREFACE

This handbook is a guide for facilities maintenance managers. Its objective is to set minimum facilities maintenance standards. It also provides recommendations on how to meet the standards to ensure that NASA maintains its facilities in a manner that protects and preserves its investment in the facilities in a cost-effective manner while safely and efficiently performing its mission.

This handbook implements NMI 8831.1, which states NASA facilities maintenance policy and assigns organizational responsibilities for the management of facilities maintenance activities on all properties under NASA jurisdiction. It is a reference for facilities maintenance managers, not a step-by-step procedural manual.

Because of the differences in NASA Field Installation organizations, this handbook does not assume or recommend a typical facilities maintenance organization. Instead, it uses a systems approach to describe the functions that should be included in any facilities maintenance management system, regardless of its organizational structure.

For documents referenced in the handbook, the most recent version of the documents is applicable.

This handbook is divided into three parts:

- | | |
|----------|--|
| Part I | Specifies common definitions and facilities maintenance requirements; and amplifies the policy requirements contained in NMI 8831.1. |
| Part II | Provides guidance on how to meet the requirements of Part I. Part II contains recommendations only. |
| Part III | Contains general facilities maintenance information. |

One objective of this handbook is to fix commonality of facilities maintenance definitions among the Centers. This will permit the application of uniform measures of facilities conditions, of the relationship between current replacement value and maintenance resources required, and of the backlog of deferred facilities maintenance.

The utilization of facilities maintenance system functions will allow the Centers to quantitatively define maintenance objectives in common terms, prepare work plans, and develop management information in order to statistically identify and analyze variances from those plans. It will also add credibility to the NASA facilities maintenance budgeting process. The key to a successful maintenance program is the understanding and support of the senior Center managers.

Comments on and recommendations for improvements to this handbook are welcome. Comments will be reviewed at the annual NASA Facilities Maintenance Conference but may be submitted at any time. Refer comments to the NASA Headquarters Maintenance Management Branch (Code JXG).



Billie J. McGarvey

Director

Facilities Engineering Division

Distribution

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PART I

REQUIREMENTS

Part I specifies common definitions and facilities maintenance requirements; and amplifies the policy requirements contained in NMI 8831.1. These requirements were designed to be flexible, and serve as a foundation for field installations to design their facilities maintenance management system. Guidance for meeting these minimum requirements is contained in Part II.

Although NMI 8831.1, Management of Facilities Maintenance, is the basic NASA Headquarters directive specifying NASA facilities maintenance policy, there are other NASA Headquarters directives that also apply. These directives are cited where applicable.

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CHAPTER 1. REQUIREMENTS

1.1 FACILITIES MAINTENANCE DEFINITIONS

In accordance with NMI 8831.1, Management of Facilities Maintenance, the Field Installations should use the following standard NASA terms with respect to facilities maintenance:

a. Maintenance Items

- (1) Facility
- (2) Equipment

b. Facilities Maintenance Work Elements

- (1) Preventive Maintenance
- (2) Predictive Testing & Inspection (subset of Preventive Maintenance)
- (3) Grounds Care
- (4) Programmed Maintenance
- (5) Repair
- (6) Trouble Calls (subset of Repair)
- (7) Replacement of Obsolete Items
- (8) Service Requests
- (9) Central Utility Plant Operations & Maintenance

c. Planning Factors

- (1) Backlog of Deferred Facilities Maintenance
- (2) Current Replacement Value
- (3) Condition Assessments

Each of these terms has a standard NASA-wide definition. It is essential that these

definitions be used for commonality in planning, programming, budgeting, costing, and reporting facilities maintenance. Most importantly, use of the standard definitions will make it possible for NASA to state how much money it is actually spending on facilities maintenance. Field Installations are encouraged to use the facilities maintenance work elements to identify, classify, and analyze facilities maintenance for trends. These work elements should also be considered in preparing the Annual Work Plan. The standard definitions follow.

1.1.1 FACILITY

A term used to encompass land, buildings, other structures and other real property improvements, including utility systems and collateral equipment. The term does not include operating materials, supplies, special tooling, special test equipment, and noncapitalized equipment. (See *Financial Management Manual* (FMM) 9250-32 for criteria for capitalized equipment.) The term facility is used in connection with land, buildings (facilities having the basic function to enclose usable space), structures (facilities having the basic function of a research or operational activity), and other real property improvements.

1.1.2 EQUIPMENT

Collateral equipment and noncollateral equipment are defined in NHB 7320.1, *Facilities Engineering Handbook*, as follows:

1.1.2.1 Collateral Equipment. Encompasses building-type equipment, built-in

equipment, and large, substantially affixed equipment/property, and is normally acquired and installed as part of a facility project.

a. Building-Type Equipment. A term used in connection with facility projects, and is that equipment which is normally required to make a facility useful and operable. It is built-in or affixed to the facility in such a manner that removal would impair the usefulness, safety, or environment of the facility. Such equipment includes elevators; heating, ventilating, and air conditioning systems; transformers; compressors; and other like items generally accepted as being an inherent part of a building or structure and essential to its utility. It also includes general building systems and subsystems such as electrical, plumbing, pneumatic, fire protection, and control and monitoring systems.

b. Built-In or Large, Substantially Affixed Equipment. A term used in connection with facility projects of any type other than building-type equipment which is to be built-in, affixed to, or installed in real property in such a manner that the installation cost, including special foundations or unique utilities service, or the facility restoration work required after its removal, is substantial.

1.1.2.2 Noncollateral Equipment. Includes all equipment other than collateral equipment. Such equipment, when acquired and used in a facility or a test apparatus, can be severed and removed after erection or instal-

lation without substantial loss of value or damage thereto or to the premises where installed. Noncollateral equipment imparts to the facility or test apparatus its particular character at the time, e.g., furniture in an office building, laboratory equipment in a laboratory, test equipment in a test stand, machine tools in a shop facility, computers in a computer facility, and is not required to make the facility useful or operable as a structure or building.

1.1.3 FACILITIES MAINTENANCE

The recurring day-to-day work required to preserve facilities (buildings, structures, grounds, utility systems, and collateral equipment) in such a condition that they may be used for their designated purpose over an intended service life. It includes the cost of labor, materials, and parts. Maintenance minimizes or corrects wear and tear and thereby forestalls major repairs (Facilities Maintenance does not include work on noncollateral equipment).

The elements of facilities maintenance and their Field Installation-level dollar limitations are as defined in the following paragraphs. Field Installations should be prepared to report their planned and actual facilities maintenance effort by these elements when so requested by NASA Headquarters.

1.1.3.1 Preventive Maintenance (PM). The planned, scheduled periodic inspection, adjustment, cleaning, lubrication, parts replacement, and minor repair (no larger than trouble call scope) of equipment and systems for which a specific operator is not assigned. Preventive Maintenance (PM) consists of many check point activities on items that, if disabled, would interfere with an essential

Center operation, endanger life or property, or involve high cost or long lead time for replacement. PM is the cornerstone of any good maintenance program. A weak or nonexistent PM program could result in much more emergency work and costly repairs.

Any dollar amount

1.1.3.2 Predictive Testing & Inspection (PT&I). Those testing and inspection activities for facility items that generally require more sophisticated means to identify maintenance requirements than in Preventive Maintenance. For example, specialized tests are used to locate thinning of pipe walls and fractures (e.g., eddy current testing, radiographic inspections, ultrasonic testing, television cameras, or aural leak detectors); to detect roof weaknesses or wet insulation areas (e.g., infrared, thermographic viewers, or nuclear density devices); to identify large equipment wear problems (e.g., vibration analyzers, and oil analysis for wear metals and lubricant properties); and to locate charge or heat buildup in electric equipment (e.g., staticscopes or infrared thermography).

Any dollar amount.

1.1.3.3 Grounds Care. Grounds Care is the maintenance of lawns, shrubs, trees, sprinklers, rights-of-way and open fields, drainage ditches, other similar improvements to land, and pest control when performed outside of buildings. The maintenance tasks include mowing, spreading fertilizer, trimming hedges and shrubs, clearing ditches, snow removal, and related work. Included in this category is the cost of maintaining Grounds Care equipment such as mowers and tractors.

Any dollar amount.

1.1.3.4 Programmed Maintenance (PGM). Programmed Maintenance are those maintenance tasks whose cycle exceeds 1 year, such as painting a building every 5th year. (This category is different from PM in that if a planned cycle is missed the original planned work still remains to be accomplished, whereas in PM only the next planned cycle is accomplished instead of doing the work twice such as two lubrications, two adjustments, or two inspections.) Some examples of Programmed Maintenance include: painting, roof maintenance (flood-coat, flashing, patching, some repair by replacement), road and parking lot maintenance (overlays, seal coating, and patching), utility system maintenance (pigging of constricted lines), and similar functions.

Any dollar amount.

1.1.3.5 Repair. That facility work required to restore a facility or component thereof, including collateral equipment, to a condition substantially equivalent to its originally intended and designed capacity, efficiency or capability. It includes the substantially equivalent replacements of utility systems and collateral equipment necessitated by incipient or actual breakdown.

Up to \$200,000.

1.1.3.6 Trouble Calls. Trouble Calls are generally called in by telephone by occupants of a facility (or facility managers or maintenance workers). This category is composed of two types of work: Routine calls and emergency calls.

Routine calls are minor facility problems that are too small to be estimated (usually

less than about 20 man-hours or \$2,000) and are generally responded to by grouping according to craft and location.

Emergency calls require immediate action to prevent loss of, or damage to Center property; to restore essential services that have been disrupted; or to eliminate hazards to personnel or equipment. Emergency work is usually a response type work effort, often initially worked by Trouble Call technicians. Due to its nature, emergency work is not restricted to a level of effort such as Routine Calls (although in many cases fall within the man-hour and/or \$ limit of routine calls).

Up to \$200,000.

1.1.3.7 Replacement of Obsolete Items (ROI). There are many components of a facility which should be programmed for replacement as a result of becoming obsolete (no longer parts-supportable at the end of service life), or do not meet electrical or building codes or are unsafe but are still operational and would not be construed as a Repair. Examples include:

- Electric switchgear, breakers, and motor starters.
- Elevators.
- Control systems.
- Boiler and central heating, ventilating, and air conditioning (HVAC) systems and controls.
- Fire detection systems.
- Cranes and hoists.
- Air conditioning (A/C) systems using chlorofluorocarbon (CFC) refrigerants.

Up to \$200,000.

1.1.3.8 Service Requests. Service Requests are not maintenance items, but are so often performed by facilities maintenance organizations they become a part of the baseline. Service Requests are requests for facilities related work which is new in nature, and as such should be funded by the requesting organization. They are requests initiated by anybody on the Center, are usually submitted on a form, often require approval by someone before any action is taken, usually are planned and estimated, materials procured, and shop personnel discretely scheduled to accomplish the work. Some examples include: installation of an outlet to support a new copier machine; providing compressed air outlet to new test bench; office renovations; special cabinetry; and similar items.

Up to \$200,000.

1.1.3.9 Central Utility Plant Operations & Maintenance. This category is unique in that it includes the cost of operations in addition to maintenance costs. It should be used only to capture the costs of operating and maintaining institutional central utility plants, such as a central heating or steam plant, wastewater treatment plant, or a central air conditioning (chiller) plant. The concept is that operators are assigned full time to operate the plant, but they perform maintenance between various operating tasks, making it almost impossible to segregate operational and maintenance costs; therefore, the costs of the full-time operators (and their materials) are shown here.

Any dollar amount.

1.1.4 PLANNING FACTORS

1.1.4.1 Backlog of Deferred Facilities Maintenance. The backlog of deferred facilities maintenance is defined as the unfunded facilities maintenance work required to bring facilities and collateral equipment to a condition that meets acceptable facilities maintenance standards. The key word is unfunded. If resources are or will be available to do the work at the time the work is required, the work is considered to be scheduled (current year) and is not part of the backlog.

1.1.4.2 Current Replacement Value (CRV). A facilities maintenance budget equal to a percentage of the current replacement value is one generally accepted method of determining the approximate level of funding required to maintain facilities at an acceptable standard. CRV is calculated by escalating facilities and collateral equipment acquisition costs and incremental book value changes to the current year using the *Engineering News Record* (ENR) building cost index (BCI) factors. The book value of each facility is continuously updated by the cost of any additions, modifications, or demolition of \$1,000 or more. The CRV calculations are made by applying the BCI for the date of acquisition to the acquisition cost, the BCI for the date of any subsequent change in book value to the value of that change, and algebraically summing the results. Book values and the resulting CRV's are not changed by maintenance and repair actions. CRV's will be updated each year on March 31st using the latest ENR 20-city average BCI values.

The CRV may be calculated using the NASA Real Property Database (RPDB) Software Program, or other suitable, ap-

proved system. Locally approved systems must support Chapter 1 of NHB 8800.15 (Appendix C, reference 31) and NMI 8831.1, Management of Facilities Maintenance.

1.1.4.3 Condition Assessments are standardized surveys conducted of facilities at each Center by experienced facilities maintenance personnel, which may be from the Center, Headquarters, or by support contractor to observe the condition of each facility in order to determine the overall average condition of each Center.

The surveys should encompass the different components of the facilities, such as roofs, pumps, air conditioning condensers, interior finishes, electrical motors and systems, etc. They should also include the Center's infrastructure, such as roads, storage tanks, grounds, sidewalks, drainage structures, utility systems, and more.

1.2 RESOURCES MANAGEMENT

Although Field Installations manage their resources in different ways, there are many things that will be the same among all Field Installations. The following are the primary ones:

1.2.1 FACILITIES MAINTENANCE COST ACCOUNT CODES

NASA Headquarters must report to OMB and the Congress on how NASA spends its facilities maintenance funds. Functional Management System (FMS) codes have been established to do this. They are defined in the *NASA Financial Management Manual - Agency-wide Coding Structure* (FMM 9100) (Appendix C, reference 2). Field Installations

tions will use the FMS codes listed in Table 1-1 for accounting and reporting to NASA Headquarters on facilities maintenance funds. In addition, Field Installations are encouraged to establish methods in their facilities maintenance management systems to capture, for each FMS Maintenance Code, all the costs associated with the nine facilities maintenance work elements listed in paragraph 1.1b in order to manage and analyze their facilities maintenance programs.

1.2.2 FUND SOURCES

FMM 9100 defines the standard fund sources. Institutional Operating Plans/Program Operating Plans (IOP's/POP's) require that budget requests be broken down by fund source.

1.2.3 FUNDING THRESHOLDS

NHB 8820.2, *Facility Project Implementation Handbook*, (Appendix C, reference 33) specifies facility project funding sources and thresholds. Table 1-2 summarizes the facilities maintenance work element funding thresholds.

1.2.4 FUNDING LEVELS

In NMI 8831.1, NASA Headquarters recognizes the annual funding level of 2 percent-4 percent of CRV recommended by the Building Research Board, National Research Council (Appendix C, reference 8), as a reasonable funding target necessary to maintain facilities at an adequate maintenance standard, unless an independent analysis indicates otherwise. The 2 percent-4 percent does not include the additional funds that are required to eliminate the backlog of deferred facilities maintenance.

Only work of a maintenance or repair nature should be included in the 2 percent to 4 percent-of-CRV funding analysis. This includes all of the following standard work elements:

- Preventive Maintenance
- Predictive Testing & Inspection
- Grounds Care
- Programmed Maintenance
- Repair
- Trouble Calls
- Replacement of Obsolete Items
- Construction of Facilities (CoF) Repair Projects

The 2 percent-4 percent should not contain Service Requests because they are for new work.

CoF rehabilitation projects may be within the 2 percent-4 percent scope to the extent that they do not increase the capacity or capability of a facility. For example, if a rehabilitation project includes air conditioning where there was none before, the cost of the air conditioning is regarded as construction, not maintenance or repair. Thus, individual judgments must be made on each CoF rehabilitation project. Field Installations should contact NASA Headquarters (Code JXG) for specific guidance in crediting their projects toward the 2 percent to 4 percent-of-CRV funding analysis.

1.2.5 REIMBURSABLE FUNDS

Field Installations should, when possible, perform construction, addition, and modification work below the \$200,000 CoF threshold, Service Request work, and non-facilities maintenance work, with funds provided by the customer requesting the work,

**FUNCTIONAL MANAGEMENT SYSTEM (FMS) CODES
FOR FACILITIES MAINTENANCE AND PARTIAL LISTING
OF OTHER RELATED AREAS**

<u>CODE</u>	<u>TITLE</u>
20 04 XX	Facilities Maintenance
20 04 01	Support Facilities (Institutional)
20 04 02	Pavement and Roads (Institutional)
20 04 03	Grounds (Institutional)
20 04 04	Industrial/Production/Manufacturing Facilities (Institutional)
20 04 05	Utility Distribution & Collection Systems (Institutional)
20 04 06	Bench Stock Materials and Other Items (Institutional)
20 04 07	Launch and Payload Facilities (Program Unique)
20 04 08	Aviation Facilities (Program Unique)
20 04 21	Research and Test Facilities (Program Unique)
20 04 24	Industrial/Production/Manufacturing Facilities (Program Unique)
20 05 XX	R&D/SFCDC and R&PM/OIG Funded Facilities and Environmental Work (Service Requests, Repairs, Modifications, and Minor Construction, etc.)
20 05 01	Routine Facilities Work (Institutional)
20 05 03	Environmental Compliance and Restoration Work (Institutional)
20 05 04	Routine Facilities Work (Institutional Repair)
20 05 21	Routine Facilities Work (Program Unique)
20 05 22	Minor Facilities Projects (Unforeseen Program Unique Needs)
20 05 23	Environmental Compliance and Restoration Work (Program Unique)
20 05 24	Routine Facilities Work (Program Unique Repair)
20 05 25	Environmental Compliance and Restoration Work (Unforeseen Program Unique Needs)
20 05 26	Minor Facilities Projects (Unforeseen Program Unique Repair Needs)
20 06 XX	Utilities
20 06 07	Central Utility Plant Operations & Maintenance (Institutional)

(See NASA FMM 9100 for latest version of these codes)

Table 1-1. Functional Management System Codes for Facilities Maintenance

**FACILITIES MAINTENANCE
WORK ELEMENTS****FIELD INSTALLATION
FUNDING LIMITATIONS**

Preventive Maintenance	Any dollar amount
Predictive Testing & Inspection	Any dollar amount
Grounds Care	Any dollar amount
Programmed Maintenance	Any dollar amount
Repair ^{1, 2}	Up to \$200,000
Trouble Calls ^{1, 2}	Up to \$200,000
Replacement of Obsolete Items ¹	Up to \$200,000
Service Requests ^{1, 3}	Up to \$200,000
Central Utility Plant Operations & Maintenance ⁴	Any dollar amount

Notes:

1. Limitation is per project or per incident. For work estimated to cost \$50,000 or more, NASA Form 1509 documentation is required.
2. Costed under Routine Facilities Work functional codes 20 05 04, 20 05 24, or 20 05 26.
3. Costed under Routine Facilities Work functional codes 20 05 01, 20 05 21, or 20 05 22.
4. Costed under functional code 20 06 07.

Table 1-2. Facilities Maintenance Funding Thresholds

so as not to impact the limited funds available for facilities maintenance.

1.2.6 BUDGETING

Field Installations will budget for facilities maintenance funds annually in response to the NASA Headquarters budget call guidance and approved IOP's/POP's.

1.3 FACILITIES MAINTENANCE MANAGEMENT SYSTEM

Centers and other Field Installations should use automated facilities maintenance management systems where practical and justified.

1.4 INVENTORY

As required by Chapter 1 of NHB 8800.15, Field Installations need to maintain a complete inventory of facilities and maintainable equipment for planning, tracking, and accounting purposes. The inventory should quantify the magnitude and detail for the total facilities maintenance program, identifying what will be operated, inspected, and maintained. It is the primary element of an effective facilities maintenance management system and is a basis for resource allocation.

1.5 FACILITIES MAINTENANCE STANDARDS

Field Installations should use generally accepted facilities maintenance standards, as detailed in this handbook and the references contained in Appendix C, appropriate for the NASA objective of providing world class facilities. The standards, which form a part of the PM programming, should be the basis for evaluating the condition of the facilities and for determining the minimum

and desired material condition of facilities and maintainable collateral equipment. Field Installations should develop and use maintenance cycles that take into account local use and environmental conditions.

In addition to the facilities maintenance standards used to identify deficiencies not discernable visually, Field Installations should endeavor to minimize the occurrence of the following visual deficiencies:

- Peeling or flaking paint.
- Rust stains or corrosion.
- Stained or mildewed concrete surfaces.
- Leaking roofs.
- Leaking pump seals.
- Failed asphalt paving.
- Debris on grounds or in mechanical areas.
- Spalled or scaling concrete.
- Tripping hazards.
- Leaking steam traps.
- Stained or broken ceiling tile.
- Worn or broken floor tile.
- Painted surfaces worn through to base materials.
- Carpet wear paths or ripples.
- Electrical or mechanical equipment not meeting current codes.
- Unsecured or failed pipe insulation.
- Overheated motors or other electrical devices.
- Abandoned-in-place conduit and cables (unless facility is to be excessed).
- Traffic signs and markings not meeting the "Manual on Uniform Traffic Control Devices".
- Faded or illegible building signs.
- Leaking and non-operational components.

As a general rule, Field Installations should have appropriate landscaping, color-coded and identified piping, efficient and reliable heating and air conditioning equipment, and other amenities suitable for the world class facilities that are NASA's goal.

1.6 WORK CONTROL SYSTEM

Field Installations should have work control systems that receive, classify, identify, estimate, approve, schedule, track, account for, analyze, and report all work throughout the facilities maintenance process, from inception to completion.

1.7 WORK CLASSIFICATION

Field Installations will classify work by FMS code, fund source, and NASA facility classification codes for real property. Field Installations are encouraged to also include classifications by the facilities maintenance work elements listed in paragraph 1.1b for reporting as required by NASA Headquarters or Field Installation management.

1.8 PLANNING AND ESTIMATING

Field Installation work control systems should contain a planning and estimating function to estimate labor, material, tools, and equipment requirements; to define job phasing by craft; and to prepare work orders. Thresholds should be established to indicate the scope of work limit justifying formal planning and estimating.

1.9 WORK IDENTIFICATION

Field Installation work control systems should include a unique designator for each item of work. The identifier should be used to track work from inception to completion.

1.10 WORK AUTHORIZATION

Work control systems should include the designation of individuals authorized to approve work based on a hierarchy of cost, urgency, or other management considerations.

1.11 MATERIAL MANAGEMENT

Work control systems should interface with material management systems throughout the facilities maintenance process, including selecting, ordering, receiving, storing, inventorying, staging, issuing, turning in, disposing of, and coordinating all the phases of material management.

1.12 WORK SCHEDULING

Work control systems should include methods of scheduling work to ensure efficient work accomplishment, with the appropriate priority, through coordination of personnel, material, equipment, tools, job-site access, and customer notification.

1.13 EVALUATION

Work control systems should contain provisions for evaluating completed work to compare actual work performance with estimates, for quality assurance (whether performed in-house or by contract) and to ensure conformance with work order instructions, standards, customer satisfaction, and accuracy of completed work for costing and reporting purposes.

1.14 FACILITY CONDITION ASSESSMENT

Field Installations will conduct standardized facility condition assessments at least once

every 5 years to provide objective, auditable evaluations of facilities condition, to estimate facilities maintenance requirements, and to validate and update the backlog of deferred facilities maintenance.

1.15 FIVE-YEAR FACILITIES MAINTENANCE PLAN

Field Installations should maintain Five-year Facilities Maintenance Plans for resource planning beyond the Annual Work Plans. The Five-year Facilities Maintenance Plans should consider the following items, among others:

- Management of the backlog of deferred facilities maintenance.
- Assumption of maintenance responsibility for completed CoF projects.
- Determination of work to be accomplishment by in-house vs. contract to allow for contract development and in-house work force adjustment.
- "Programmed" maintenance requirements.

1.16 ANNUAL WORK PLAN

Field Installations should develop and maintain Annual Work Plans as the basis for planning, budgeting, and scheduling facilities maintenance work. Annual Work Plans should be based upon IOP's and POP's.

1.17 MANAGEMENT INFORMATION SYSTEM (MIS)

Field Installations should develop management information systems to provide complete, accurate, and timely information for work tracking, reporting, management analysis, and decision making. As a minimum, the systems will include the capability

to produce reports by FMS codes, fund source, and NASA facility classification codes for real property. The systems should also include the capability to produce reports by the maintenance work elements. The MIS is not the same as the Automated Maintenance Management System (AMMS)/Computerized Maintenance Management System (CMMS). The MIS is a database and report generating system designed to provide management personnel with up-to-date information on an organization's performance. On the other hand, AMMS/CMMS is an automated, computerized system designed to assist maintenance managers in performing the several maintenance management functions of work reception, work control, work performance, work evaluation, and work reporting in coordination with material management, personnel management, and financial management. AMMS/CMMS is a principal source of information for the facilities maintenance portions of the MIS.

1.18 PHYSICAL PLANT INFORMATION

Field Installations should maintain automated physical plant information. The information should include a comprehensive, detailed, quantitative inventory containing a description of each facility and maintainable equipment item. The database should include maintenance standards and supporting information such as parts lists, part sources, maintenance procedures, narrative descriptions, technical manuals, and drawings. To the maximum feasible extent, the physical plant information should be an element of the CMMS.

1.19 REAL PROPERTY DATABASE

NMI 8831.1 requires that Field Installations maintain the NASA Real Property Database (NASA RPDB), or a Headquarters Code JXG approved alternate system. This database will be used to compute the current replacement value (CRV) of the Field Installation.

1.20 LICENSES, PERMITS, AND CERTIFICATIONS

Central utility plant operators and superintendents, such as at water treatment plants, boiler plants, and wastewater treatment plants, should be licensed by applicable state and local governments. Also, when required by state or local governments, permits for such things as incinerators, licenses for other facilities maintenance-related operations such as pest control and herbicide applicators, and certificates for such things as pressure vessels, lifting devices, and elevators will be obtained. To the maximum extent possible, such licenses, permits, and certificates should be issued by the state or local government rather than Field Installations to avoid administrative duplication. Field Installations should issue only those licenses, permits, and certificates that are NASA-unique and therefore not available through other existing regulatory organizations.

PART II

GUIDANCE

Part II provides guidance on how to meet the requirements of Part I. Utilization of the guidance is discretionary, but strongly advised, by the Field Installations. This guidance is provided to assist the Field Installations in improving what they are doing already or to suggest ways to accomplish the requirements stated in Part I. This guidance is consistent with state-of-the-art facilities maintenance management systems and methods at handbook press time. It avoids duplication of effort by identifying systems, methods, and techniques that have been proven in wide use throughout the facilities maintenance community in both government and private industry.

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CHAPTER 2. RESOURCES MANAGEMENT

2.1 INTRODUCTION

This chapter discusses management as it relates to facilities maintenance. It covers NASA directives, policy, budget composition, reimbursable funds, and the Program Operating Plan (POP).

2.2 PUBLICATIONS

Table 2-1 lists NASA Headquarters publications that apply to facilities maintenance resources management.

2.3 FACILITIES MAINTENANCE BUDGET COMPOSITION

2.3.1 BUDGET CALL GUIDANCE

A budget call is a request from NASA Headquarters for budget information. Facilities maintenance personnel are involved with Field Installation development of information for the following basic budget calls:

- The Research & Development (R&D) budget call.
- The Space Flight, Control, and Data Communication (SFCDC) budget call.
- The Construction of Facilities (CoF) budget call (primarily for construction, repair, rehabilitation, and modification projects).

<u>Publication</u>	<u>Title</u>
NMI 7234.1	Facilities Utilization Program
NMI 7330.1	Delegation of Authority - Approval Authorities for Facility Projects
NHB 7400.1	Budget Administration Manual
NHB 8800.15	Real Estate Management Program Implementation Handbook
NMI 8831.1	Management of Facilities Maintenance
FMM 9100 Series	NASA Financial Management Manual

Table 2-1. NASA Headquarters Instructions, Handbooks, and Manuals

- The Research and Program Management (R&PM) budget call.
- Special budget calls as requested throughout the year by NASA Headquarters or the Field Installation Comptroller.

2.3.2 FACILITIES MAINTENANCE BUDGET CALL

Each year in March, NASA Headquarters receives budget guidance from the Office of Management and Budget (OMB). In June, the NASA Chief Financial Officer (CFO)/Comptroller and the Associate Deputy Administrator provide guidance to the Institutional Associate Administrators and Program Associate Administrators, including the Director, Facilities Engineering Division (Code JX). In July, the Institutional Program Offices - the Associate Administrators for Space Flight (Code M); Aeronautics and Space Technology (Code R); and Space Science and Applications (Code S); issue the facilities maintenance budget call to the Field Installations they manage with guidance for preparing estimates as described below (while Code O is not an Institutional Program Office, they do have institutional responsibilities). The Field Installations managed by Codes M, O, R, and S are as follows:

Code M

Johnson Space Center (JSC)
 Downey
 Palmdale
 White Sands Test Facility (WSTF)
 Kennedy Space Center (KSC)
 Marshall Space Flight Center (MSFC)
 Michoud Assembly Facility (MAF)
 Santa Susana Field Laboratory
 Slidell Computer Complex (SCC)

Stennis Space Center (SSC)

Code O

Deep Space Network
 Canberra Deep Space Communications Complex
 Goldstone Deep Space Communications Complex
 Madrid Deep Space Communications Complex
 Spaceflight Tracking and Data Network
 Bermuda
 Dakar, Senegal
 Merritt Island, Florida
 Ponce de Leon, Florida
 Space Network Ground Terminals (White Sands)

Code R

Ames Research Center (ARC)
 Dryden Flight Research Facility (DFRF)
 Langley Research Center (LaRC)
 Lewis Research Center (LeRC)
 Plum Brook Station (PBS)

Code S

Goddard Space Flight Center (GSFC)
 Wallops Flight Facility (WFF)
 National Scientific Balloon Facility (NSBF)
 Jet Propulsion Laboratory (JPL)
 Edwards Test Station (ETS)
 Table Mountain

Although budget guidance may vary from year-to-year, the basic budget content and format described below are relatively constant. The facilities maintenance budget call requests cost information broken down by FMS code and fund source for 3 fiscal

years. These categories are described below.

2.3.3 FUNCTIONAL MANAGEMENT SYSTEM (FMS) CODES

The annual facilities maintenance budget is composed of the FMS codes defined in the NASA *Financial Management Manual*, (FMM) 9121-52A. Each of the codes is added to produce the total Field Installation facilities maintenance budget.

2.3.4 FUND SOURCES

The facilities maintenance budget call submittal requires that each fund source be cited for each FMS code. The possible fund sources are listed in FMM 9100, Section 9121-56. There are 15 fund sources. They are listed in Table 2-2. The most commonly used fund sources for facilities maintenance are:

- 01 (Personnel and Related Services)
- 02 (Limitation Travel)
- 04 (Research and Development Program)
- 14 (SFCDC, Multi-year Funding)
- 15 (SFCDC, No-year Funding)
- 16 (Space Flight, Control, and Data Communications Program - Three year Funding)
- 21 (Office of Inspector General (OIG), Personnel and Related Services)
- 22 (Office of Inspector General (OIG), Limitation Travel)
- 23 (Office of Inspector General (OIG), Operation of Installation)

2.3.5 FISCAL YEARS

Each annual facilities maintenance budget includes cost data for 3 fiscal years (see Table 2-3):

Prior Year - The fiscal year immediately preceding the current year. Prior year costs are actual, not estimated.

Current Year - The fiscal year immediately preceding the budget year.

Budget Year - The fiscal year for which estimates are being submitted.

2.4 REQUIREMENTS DEVELOPMENT

Paragraph 1.2.1 requires that all Field Installations establish and maintain a facilities maintenance cost account system consisting of the FMS codes and that all work be classified by these codes. One of the uses of the codes is for budgeting. The annual budget call requests budget estimates by these same FMS codes. Thus, it is possible to prepare the budget by aggregating the actual expenditures by these codes for the prior year and for the current year to date. The current year-to-date figures can then be extrapolated to the full current year using the current year Annual Work Plan. The budget year requirements can then be modified by comparing the prior and current year work requirements with the budget year from the Five-year Facilities Maintenance Plan and adjusting the estimates using the standard inflation factors supplied by NASA Headquarters.

The information is therefore available for filling in the standard budget format in Table 2-3.

FUND SOURCES

<u>Fund Source</u>	<u>Title</u>
01	Personnel and Related Services
02	Limitation Travel
04	Research and Development Program
05	Construction of Facilities
06	Final Design Not Otherwise Provided For
07	Construction of Facilities Various Locations
08	Preliminary Design Not Otherwise Provided for - Construction of Facilities, Facility Planning and Design, and Environmental Compli- ance and Restoration
09	Carrier Accounts (1982 and Prior)
11	Carrier Accounts (1974 only)
14	Space Flight, Control and Data Communications Program - Multi- year Funding
15	Space Flight, Control and Data Communications Program - No-year Funding
16	Space Flight, Control and Data Communications Program - Three- year Funding
21	Office of Inspector General (OIG), Personnel and Related Services
22	Office of Inspector General (OIG), Limitation Travel
23	Office of Inspector General (OIG), Operation of Installation

Table 2-2. Fund Sources

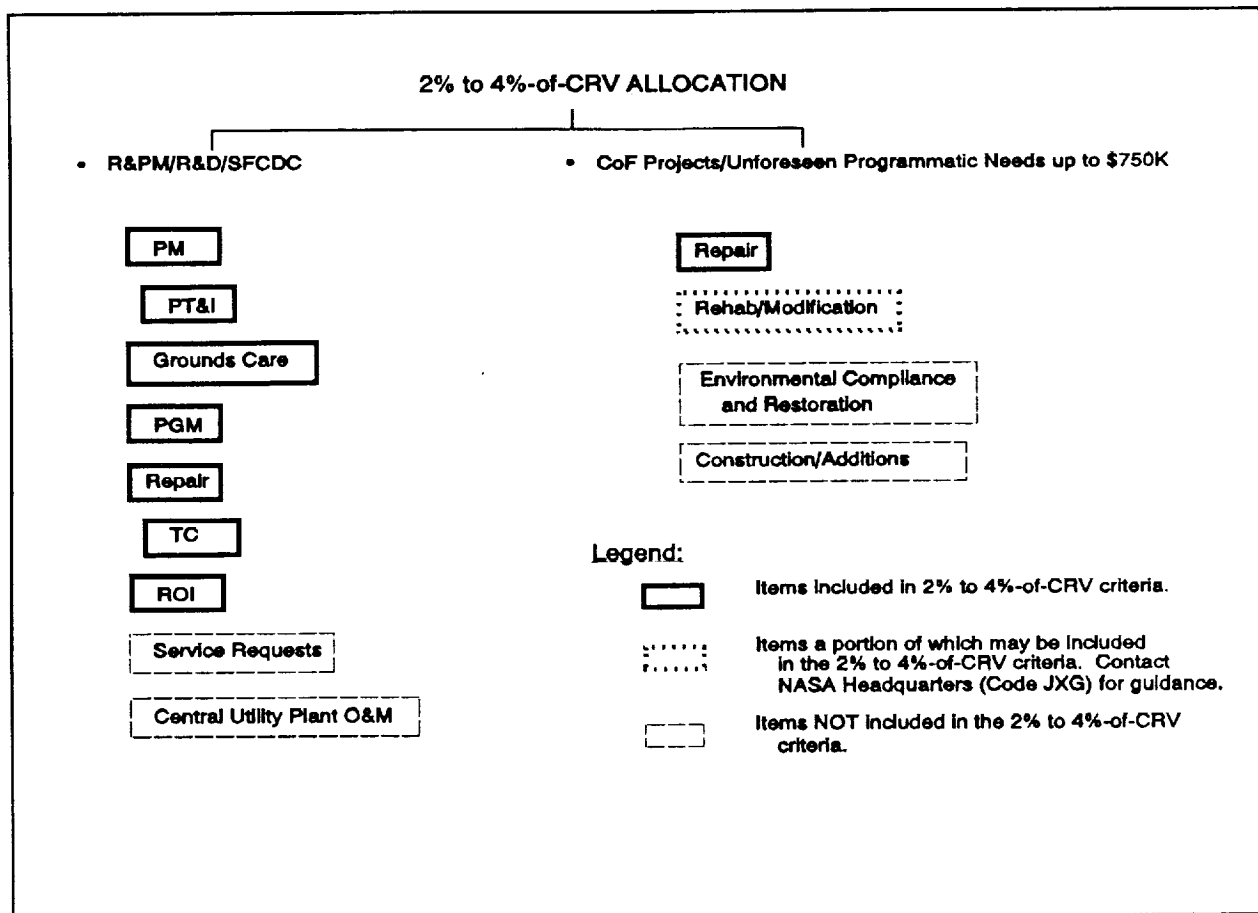


Figure 2-1. Expenditures Allocable to 2 Percent to 4 Percent-of-CRV Standard

In accordance with the requirements of paragraph 1.2.4, Field Installations should work toward a budget for facilities maintenance of 2 percent-4 percent of Current Replacement Value (CRV) as a goal. Figure 2-1 identifies the facilities maintenance expenditures that are allocated to the 2 percent to 4 percent-of-CRV goal. Only a portion of CoF rehabilitation and modification projects may be included. Field Installations should request guidance from NASA Headquarters, (Code JXG).

2.5 REIMBURSABLE SERVICES

Many Field Installations perform facilities maintenance work on facilities occupied by agencies other than NASA for which the cost is reimbursed by the occupying agencies, or they perform non-facilities maintenance work that should be reimbursed by the requesting customers. This reimbursable work is not included in the annual facilities maintenance budget that the Field Installations submit to NASA Headquarters, as detailed in Table 2-3. However, reimbursable work is included in the IOP's/POP's and should be included in the Field Installation Annual Work Plans. The IOP's/POP's and the AWP's address the total facilities

FACILITIES MAINTENANCE BUDGET
(\$000)

FMS Code _____	Description _____
	<div style="display: flex; justify-content: space-around;"> <div style="text-align: center;">FY____ (Prior Year)</div> <div style="text-align: center;">FY____ (Current year)</div> <div style="text-align: center;">FY____ (Budget Year)</div> </div>
Fund Source# _____	_____
Fund Source# _____	_____
Fund Source# _____	_____
Fund Source# _____	_____
Sub-Total	_____
Grand Total (Total of all FMS Code Sub- Totals)	_____

Table 2-3. Standard Format for Annual Facilities Maintenance Budget

maintenance workload, regardless of fund source.

2.5.1 TYPES

There are three basic types of services that the Field Installations provide to tenant and other occupying agencies on a reimbursable basis:

- Occupancy services
- Demand services
- Other services

Each is described below.

2.5.1.1 Occupancy Services. These services are essential, installation-wide support services. Services such as facilities maintenance and janitorial services are a function of the square footage of the buildings occupied. Other services may be related to the number of personnel resident at the Field Installation. Typically, the rate for occupancy services should be constant during each fiscal year to allow Field Installation customers to budget for the services. The

interagency agreements should state when the rates are scheduled to change.

2.5.1.2 Demand Services. These services provide technical support or specific deliverable products not available within the capabilities of the requestor. Typically, demand services are specifically requested by the user and are user-unique. Each demand service is separately priced and, if possible, the unit price should be constant during each fiscal year to allow Field Installation customers to estimate their fund requirements and to budget for the funds. Demand services are often requested in writing and are classified by specific functional area. The following are examples:

- Service Requests.
- Engineering Design Services.
- Construction Projects.
- Heavy Equipment Services.

2.5.1.3 Other Services. Other services are those paid directly by the customer at the time of use, such as food services, or billed periodically based upon use, such as metered utilities. There are very few facilities maintenance services billed at the time of use.

2.5.2 COST ALLOCATION

2.5.2.1 General. The determination of reimbursable costs should be based upon the concept of full cost sharing. This concept provides for common cost sharing of common services. Therefore, the costs charged to each tenant should directly reflect the tenant's proportion of the total cost to NASA for the services.

2.5.2.2 Occupancy Services. The per-unit rates charged for occupancy services should

be the same for all occupants, both tenants and NASA activities. The annual charges should be computed from prior-year costs with inflationary and expected use-change adjustments. Occupancy services are usually provided by the facilities maintenance organization or by facilities support services contractors.

Occupancy services are separated into those applicable to employee population and those applicable to the floor space occupied. These costs are calculated generally as follows.

- a. Population. A projected fiscal year total of all civil service and contractor employees is developed for each occupying organization. The total portion of the shared cost associated with personnel is divided by the total of all installation personnel. The result is the fiscal year per person rate, which is applied to each occupant.
- b. Floor Space. The square footage should be summed for each occupant by the type of space he occupies, for example:

- | | | |
|----------|---|--|
| Type I | - | Air-conditioned offices, laboratories, and technical spaces. |
| Type II | - | Non-air-conditioned shops, work areas, or technical spaces. |
| Type III | - | Non-air-conditioned warehouses and storage facilities. |

The total shared cost associated with floor space is divided by the weighted sum of all three types of floor space to determine the

Type III base rate. The Type I and Type II base rates are determined by multiplying the base rate by the weighting factor for each type. The square footage totals are multiplied by the respective rates to determine the cost for each occupant. The weighting factors are determined historically from the actual cost of cleaning and maintaining each type of space.

Personnel and floor space costs are then added together to determine the total occupancy cost.

2.5.2.3 Demand Services. The cost to tenants for demand services is generally developed by adding a surcharge to the incremental Field Installation costs incurred by the demand service work order. Since the surcharges are an integral part of Field Installation operational costs and are routinely expensed by the Installations, they are not identified separately and are not shown on reimbursable work orders. The standard surcharges developed by each Field Installation should consider the full cost sharing concept. However, there are some costs borne by NASA, such as acquisition and depreciation of shop equipment, which do not enter the standard surcharge and therefore are not reimbursed by tenants because they are within the NASA institutional budget base. Typically, monthly billings for demand services either are sent to the tenants or are charged to standing accounts.

2.5.2.4 Other Services. Many of these, such as food services, are paid for individually by each person at the time of use. Others, such as utilities, are passed through to tenants as bills are received by the Field Installation. Normally, no Field Installation surcharges are added to purchased-utility

bills. The Field Installations normally bill tenants for utilities monthly.

Table 2-4 is a sample reimbursable charge summary.

2.5.3 INTERAGENCY AGREEMENTS

While memoranda of understanding (MOU's) are helpful in defining Field Installation and tenant services and responsibilities, they are vital in the case of reimbursable services. They avoid misunderstandings about how rates are determined and how bills are rendered, certified, and paid by the tenant. They are critical for long-range planning and budgeting because they enable the Field Installations to forecast their levels of reimbursement. In the case of facilities maintenance, the accuracy of the Annual Work Plan depends upon the accuracy of the level and type of reimbursable work defined in MOU's and other interagency agreements.

2.6 INSTITUTIONAL OPERATING PLAN/PROGRAM OPERATING PLAN (IOP/POP)

The IOP's/POP's are time-phased work programs expressed in terms of dollars and other resources required to accomplish NASA objectives for the budget year. They serve as a basis for developing the NASA operating budget to support apportionment requests to OMB, to distribute resource authority within NASA, and to plan for the orderly and efficient use of resources. IOP's/POP's are prepared by NASA Associate Administrators and Program Directors with Field Installation assistance. Separate IOP's/POP's are prepared for the R&D appropriation, the SFCDIC appropriation, and

SAMPLE REIMBURSABLE CHARGE SUMMARY

1. Customer _____	2. Billing Date _____
3. Billing Period _____	
4. Customer Information:	
a. Number of Personnel On Board (Average during billing period) <u>A</u>	
b. Floor Space Occupied (sq. ft.)	
Type I	<u>B</u>
Type II	<u>C</u>
Type III	<u>D</u>
5. Rates	
a. Population (\$/person)	<u>W</u>
b. Floor Space (\$/sq.ft)	
Type I	<u>X</u>
Type II	<u>Y</u>
Type III	<u>Z</u>
c. Surcharge (%)	<u>25</u>
6. Billing	
a. Occupancy Service	
Population = A X W	= XX
Floor Space	
Type I: B X X	= XX
Type II: C X Y	= XX
Type III: D X Z	= <u>XX</u>
Sub-Total	XX
b. Demand Service	
(1) _____ X 1.25	= XX
(2) _____ X 1.25	= XX
(3) _____ X 1.25	= <u>XX</u>
Sub-Total	XX
c. Other Service	
(1) _____	XX
(2) _____	XX
(3) _____	<u>XX</u>
Sub-Total	XX
Grand Total	XX

Table 2-4. Sample Reimbursable Charge Summary

the R&PM appropriation. The NASA Comptroller and the Office of Institutional Resources and Analysis prepare the NASA operating budget from the IOP's/POP's submitted by the Associate Administrators and Program Directors.

As shown in Figure 11-2, because estimated funding requirements are prepared 14-19 months in advance of the budget year, many things can occur to change the budget estimates before IOP's/POP's are executed. Some examples are:

- Congressional decisions reflected in the final authorization and appropriations acts.
- Changes in the Field Installation resource requirements (possibly due to emergency conditions).
- Restraints imposed by NASA Headquarters.

IOP's/POP's cover a 7-year period; i.e., past year, current year, and budget year through budget year + 4 years.

The Associate Administrators and Program Directors obtain assistance from the Field Installations in preparing their IOP's/POP's.

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CHAPTER 3. FACILITIES MAINTENANCE MANAGEMENT

3.1 INTRODUCTION

This chapter describes the concepts for and approach to facilities maintenance management within NASA. It describes a generic facilities maintenance management system based on proven techniques. However, it provides the flexibility needed at each Field Installation for NASA's diverse, high technology mission.

The purpose of this chapter is twofold:

- To present factors for consideration while developing a facilities maintenance organizational structure.
- To describe the functional relationships in a facilities maintenance management system.

3.1.1 BENEFITS OF A FACILITIES MAINTENANCE MANAGEMENT SYSTEM

A facilities maintenance management system should provide for integrated processes giving managers control over the maintenance of all facilities and maintainable collateral equipment from acquisition to disposal. It should:

- Address all resources involved.
- Accommodate all methods of work accomplishment.
- Effectively interface and communicate with related and supporting systems ranging from work generation through work performance and evaluation.

The goal is to optimize the employment of scarce resources (manpower, equipment, material, and funds) to maintain the facilities and collateral equipment needed to support the Field Installation's mission. An effective facilities maintenance management system maximizes the useful life of facilities and equipment, minimizes unplanned downtime, and provides an improved work environment within a given resource level. It also produces information for management decisions.

3.1.2 FUNCTIONAL VS. ORGANIZATIONAL APPROACH

Traditionally, facilities maintenance handbooks and manuals based their guidance on a standard organization. That approach does not recognize the diversity in mission and site conditions found among the NASA Field Installations. This handbook adopts a functional approach to facilities maintenance. The thrust is to identify those functions and processes required to provide an effective facilities maintenance program without specifying an organizational structure.

The discussion that follows covers maintenance management controls, maintenance management concepts, maintenance-related functions and processes, and other factors for consideration in establishing a facilities maintenance organization. Figure 3-1 is a graphical representation of how these parameters combine to develop a facilities maintenance organization. The integration process must accommodate Field Installation-unique requirements and conditions.

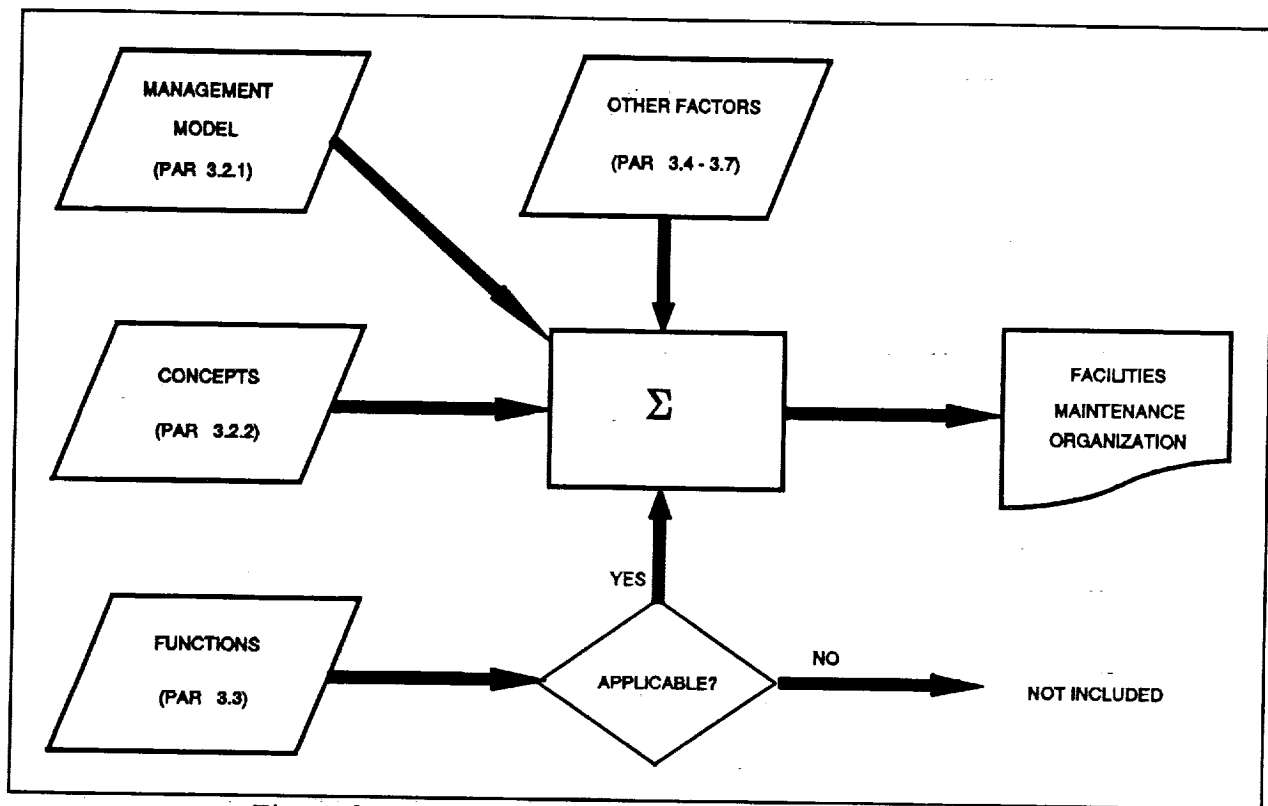


Figure 3-1. Facilities Maintenance System Development.

3.2 FACILITIES MAINTENANCE CONCEPTS

3.2.1 FACILITIES MAINTENANCE MANAGEMENT MODEL

An organization's system for work management should ensure that all efforts support the organization's goals. This requires a closed-loop system with corrective feedback and management control. This handbook discusses processes and systems that provide effective facilities maintenance management. Figure 3-2 is a closed-loop maintenance management model grouped by the elements or processes that provide controls over the system. The paragraphs that follow introduce the model's components. The order of presentation generally follows the flow of work in the maintenance management sys-

tem. However, not all work is subject to each element. Chapters 5, 7, and 8 provide additional information on implementing these elements.

3.2.1.1 Inventory. Inventory is the cornerstone of facilities maintenance management. It provides the detailed identification of what is inspected, operated, and maintained. Without an accurate inventory, maintainable items may not receive required maintenance, leading to failures, and maintenance budgeting, planning, and scheduling cannot be effective. Chapter 8 discusses inventory detail.

3.2.1.2 Maintenance Standards. Maintenance standards provide the basic information on what portions of the inventory receive maintenance and to what level they are

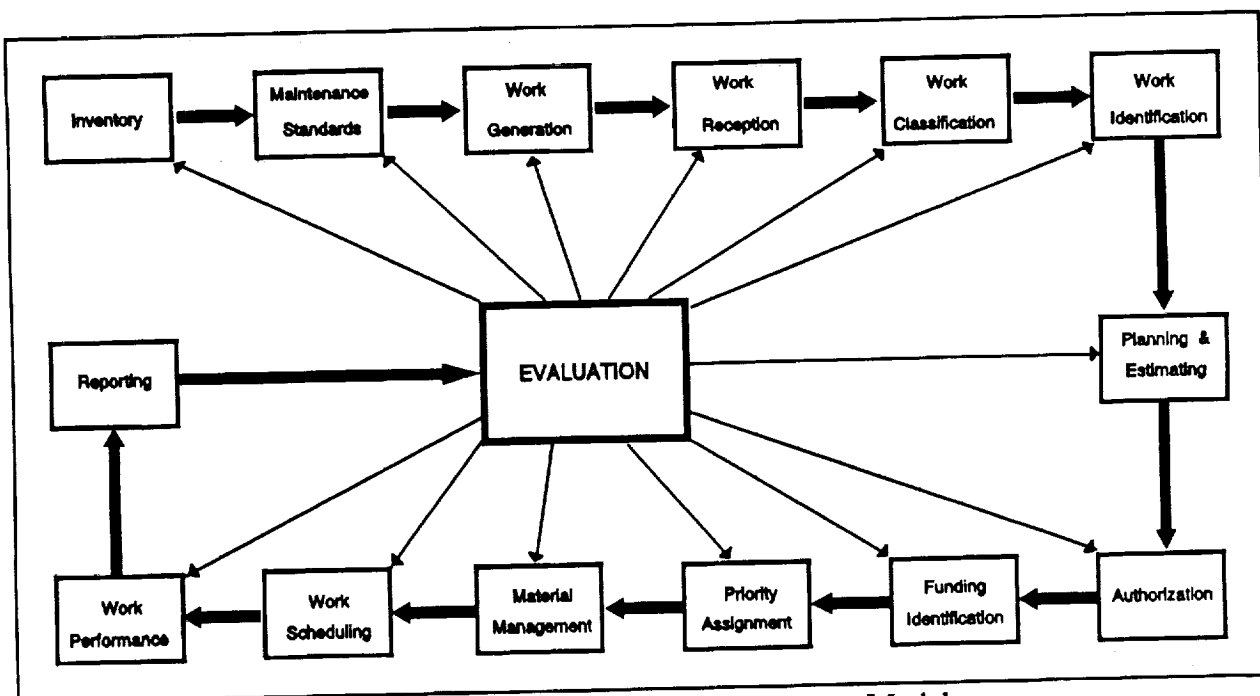


Figure 3-2. Maintenance Management Model

maintained. They also provide the benchmarks for conducting condition assessments and estimating workload. Chapter 7 discusses maintenance standards in detail.

3.2.1.3 Work Generation. Work generation is the process of determining and documenting the maintenance workload as it is input into the facilities maintenance management system.

3.2.1.4 Work Reception. Work reception accepts and records the work requirements identified by the work generation process. It provides for the administrative control of the work management data as the work progresses through the maintenance management system.

3.2.1.5 Work Classification. Work classification categorizes work along several lines based on factors such as funds type, approval level, work type, size, special interest, method of accomplishment, and repetitive

nature. These classifications facilitate analyzing, reporting, and controlling the workload. They also provide vital information for use in budget preparation and resource justification.

3.2.1.6 Work Identification. Work identification is the assignment of a unique identifier or designator, much like a serial number, to each item of work. This assists in accounting for and tracking the work to completion. It provides a unique, ready reference to the work package for use in work management, particularly in automated systems.

3.2.1.7 Planning and Estimating. Planning and estimating provides the detailed definition of maintenance tasks or steps to be taken, the resources required (material, equipment, tools, and labor), and special considerations such as safety outages and coordination. It supports budgeting, resource allocation, and work performance

decision processes, and provides a benchmark for work performance evaluation.

3.2.1.8 Authorization. Authorization is the process by which facilities maintenance work is approved for performance. This may be a phased process in which preliminary approval is given for detailed planning and estimating. Final approval is contingent upon factors such as urgency, cost, and fund availability.

3.2.1.9 Funding Identification. Funding identification covers the identification, allocation, and authorization of the proper funds. It includes Field Installation operating funds, customer reimbursable funds, and special funds.

3.2.1.10 Priority Assignment. Priority assignment is the determination of the relative precedence of an item of facilities maintenance work in comparison with all other work requirements. It includes integration of Field Installation and customer work. Its purpose is to optimize the employment of maintenance resources by ensuring that the most important work is done first.

3.2.1.11 Material Management. Material management covers the ordering, receiving, storing, staging, issuing, controlling, and disposing of the material, equipment and tools required for maintenance.

3.2.1.12 Work Scheduling. Work scheduling provides for orderly work accomplishment in a manner that optimizes all work resources. It ensures that all resources, such as materials, equipment, and tools, are available and that work clearances are coordinated prior to starting work.

3.2.1.13 Work Performance. Work performance is the accomplishment of the work by the shops or a contractor. It includes quality control and quality assurance.

3.2.1.14 Reporting. Reporting involves recording the work completion and resources used in the management information system. Reporting is a key input to the evaluation process.

3.2.1.15 Evaluation. Evaluation closes the loop on the maintenance management system. It appraises the performance of each element of the facilities maintenance management system and initiates corrective action when needed.

3.2.2 SYSTEM CONCEPTS

In creating an organization and system to perform facilities maintenance, the concepts discussed in the following paragraphs should be applied to fully implement the maintenance management control elements of Figure 3-2.

3.2.2.1 Separation of Functions. The responsibility for generating, planning and estimating, and authorizing work should be separate from the responsibility for performing work. This provides a system of checks and balances.

3.2.2.2 Planning and Estimating. Work should be planned and estimated in enough detail to define the resources and tasks required to perform the work and to communicate this information to everyone involved. This information must be clear to customers, approving authorities, schedulers, material managers, and craftsmen.

3.2.2.3 Estimating Standards. Estimating standards should be the basis for work planning and estimating to permit realistic resource allocation, scheduling, work performance, and evaluation. Several commercial, industrial, and governmental standards are available to assist in work-order estimating. Chapter 7 provides information on estimating standards.

3.2.2.4 Work Force Load Planning. Work planning should provide a sufficient volume of work sufficiently in advance of the requirements to permit balancing the facilities maintenance workload among the shops, acquiring material, arranging timely contract support, achieving priorities, and coordinating all the elements. Work should be planned on at least a quarterly basis.

3.2.2.5 Continuous Inspection. A program for the periodic inspection of facilities and maintainable collateral equipment should identify facilities condition, maintenance deficiencies, work required, and changing conditions on a timely basis. Predictive Testing & Inspection methods should be part of the continuous inspection program. Chapter 7 provides information on continuous inspection and condition assessment.

3.2.2.6 Five-year Facilities Maintenance Plan. Field Installations should develop long-range facilities maintenance plans covering both level-of-effort and specific or one-time work requirements. Such planning supports developing and justifying resource requirements on a multi-year basis. Field Installations should prepare both Annual Work Plans and Five-year Facilities Maintenance Plans. Chapter 4 provides information on both plans.

3.2.2.7 Work Grouping. Personnel performing Trouble Calls, small Service Requests, and small Repair jobs should be organizationally separated from personnel performing large facilities maintenance projects when possible. Twenty hours of effort is a suggested upper limit on the scope of these small jobs. Assigning these small jobs to a single shop avoids diluting Preventive Maintenance (PM) and Programmed Maintenance (PGM) by permitting the forces devoted to PM, PGM, and larger Repair jobs to work without frequent interruptions.

3.2.2.8 Work Scheduling. Work should be scheduled in an orderly manner considering customer requirements, time constraints, material and tool/equipment availability, priority, and work force availability.

3.2.2.9 Management Information Systems (MIS). Reporting systems should inform facilities maintenance managers of the status of all work and any significant problems so they can take timely corrective action. The MIS should gather data for work planning. Paragraph 5.11 discusses management information systems.

3.2.2.10 Quality Assurance. Both Government and contractor-performed work should be subject to quality assurance inspections.

3.2.2.11 Condition Assessment/Backlog of Deferred Facilities Maintenance. The facilities and maintainable collateral equipment condition assessment and the unfunded backlog of deferred facilities maintenance form the basis for planning, budgeting, and allocating facilities maintenance resources. These are discussed in Chapters 4 and 7.

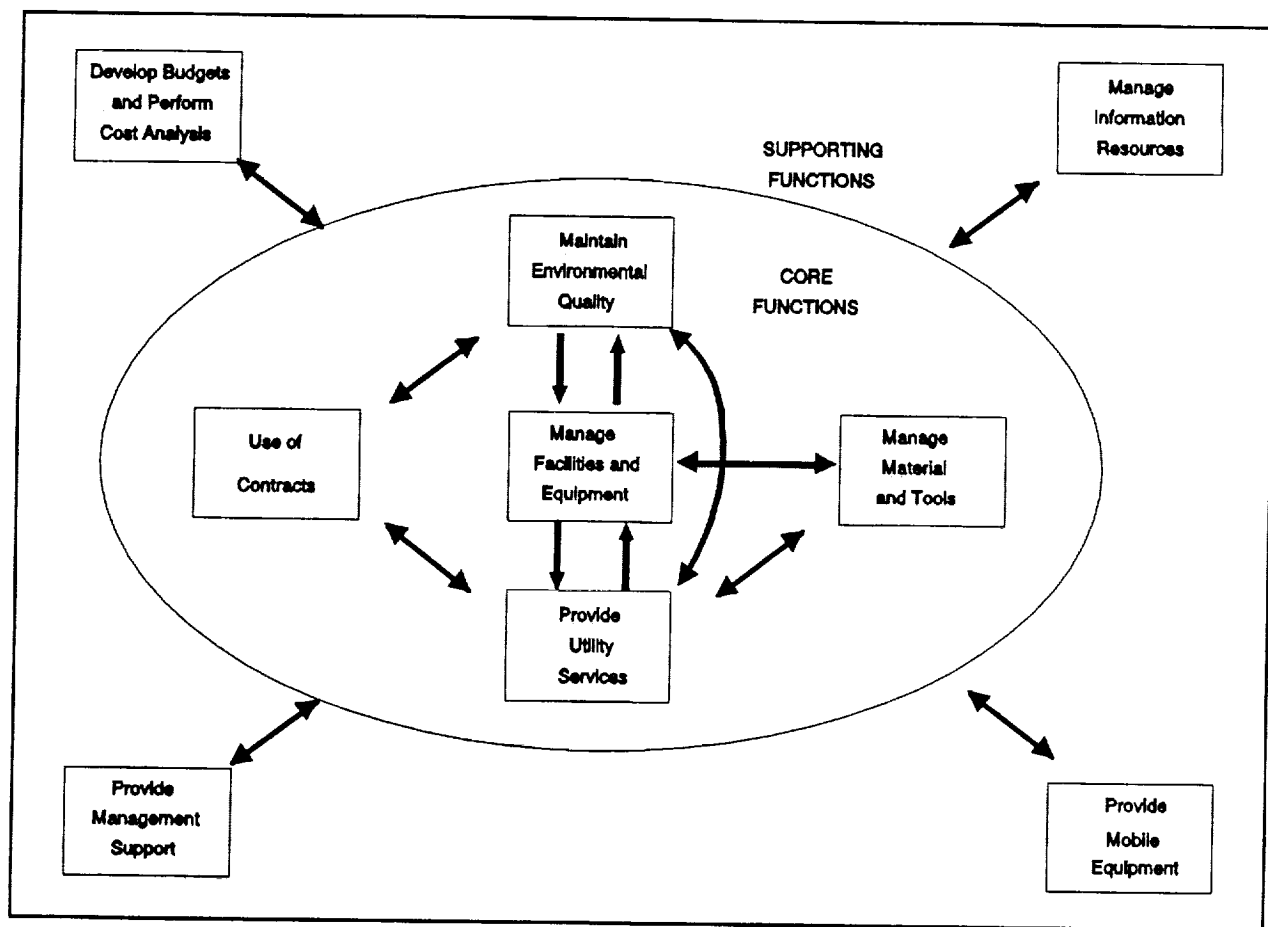


Figure 3-3. Information Flow Among Facilities Maintenance Functions.

3.3 FACILITIES MAINTENANCE FUNCTIONS

Facilities maintenance can be described as a number of interrelated functions and processes that directly or indirectly lead to the accomplishment of facilities maintenance work. Certain of these are not accomplished by the facilities maintenance organization and thus are outside the responsibility of the primary users of this handbook. This may also be the case when the scope of the work exceeds applicable facilities maintenance funding or resource thresholds; e.g., Construction of Facilities (CoF) projects. However, all functions are listed to ensure consideration of related services when establish-

ing a facilities maintenance organization and its interfaces with other organizations.

The following lists the major functions related to managing facilities maintenance. Chapter 10 contains a more detailed discussion of these functions and their components. The relationships among the following major functions depicted in Figure 3-3 illustrates the information flow:

- Manage facilities and equipment.
- Provide utilities services.
- Maintain environmental quality.
- Employ contracts.
- Provide mobile equipment.
- Provide management support.

- Manage material and tools.
- Develop budgets and perform cost analyses.
- Manage information resources.

3.4 FACTORS AFFECTING FACILITIES MAINTENANCE ORGANIZATIONS

3.4.1 PHYSICAL CHARACTERISTICS

The physical characteristics of a Field Installation such as size, geographical distribution, climate, equipment, architectural style, and construction materials have a significant impact on the facilities maintenance organization. They directly affect the need for central shop spaces, remote job sites, travel time, special facilities maintenance equipment, and facilities maintenance standards.

3.4.2 MISSION

The mission of a Field Installation influences the facilities maintenance organization because it determines the facilities maintenance standards, the equipment mix, the work force skill mix, work priorities, acceptable planned and unplanned down time, and resource levels. The organization must be structured to respond to the Field Installation's mission.

3.4.3 WORK FORCE COMPOSITION

Work force composition is driven in large part by the Field Installation's mission and physical characteristics. It affects the organizational structure and the division between contract and Government work forces. For example, a work force with a large number of electricians and air conditioning mechan-

ics may dictate an organization with a separate shop for each craft. With a small work force, these crafts may be in one shop.

3.5 ORGANIZATION AND STAFFING

3.5.1 ORGANIZATIONAL CONSIDERATIONS

Organizations plan, organize, perform, control, and evaluate work. The following factors are important considerations when designing the organizational structure.

3.5.1.1 Contract vs. In-house. The proportion of the facilities maintenance work accomplished by support contractors significantly impacts the organizational structure. As the contracted portion increases, the Government work force becomes more involved in contract administration and surveillance. The optimum mix of support contractor and Government personnel should be based on local conditions and priorities; and should be consistent with the guidance contained in the Office of Management and Budget (OMB) Circular A-76. The principles of sound facilities maintenance management apply equally to in-house and contract work.

3.5.1.2 Labor Agreements. Labor agreements may dictate certain procedures, practices, consultations, and other action. These influence the organizational structure and the Government's flexibility in making changes to the organization, work methods, or work assignments. The human resources (personnel) department can provide assistance in this area.

3.5.1.3 Functional Lines. The facilities maintenance functions are vital in support of

the Field Installation's mission. Where more than one organization has responsibility for performing facilities maintenance, close coordination is necessary. The facilities maintenance organization interfaces closely, with potential for overlap, with related processes such as master planning, major facilities acquisition, and transportation and utilities management. It may be logical to organize along functional lines; however, care must be taken to ensure that lines of communication are open and maintained among all related functions and organizational elements. Senior managers should encourage communication and liaison at all levels.

3.5.2 STAFFING CONSIDERATIONS

A number of factors will influence the staffing of a facilities maintenance organization. The Field Installation Human Resources (Personnel) Department can provide advice in staffing matters. The following factors apply to staffing plan development:

3.5.2.1 Workload Balance. The facilities maintenance organization staffing should match the workload characteristics. The manpower resources available in each craft should closely match the amount of work included in the Annual Work Plan, taking into consideration work priorities and alternative methods of accomplishment. Consider using temporary or part-time employees or one-time contracts to accomplish seasonal, surge, intermittent, or one-time work requirements.

3.5.2.2 Education and Training. The facilities maintenance organization needs to ensure that personnel have and maintain the skills needed to cope with changing tech-

nology and effectively carry out the facilities maintenance program. Skill requirements are identified through periodic reviews of all the organization workload. Comparing skill requirements with the assigned personnel skill inventory will identify shortages for correction through education, training, recruiting, or other action. Skill inventories and requirements identification should address all facilities maintenance program phases, including shop crafts, administrative skills, and use of computers.

3.5.2.3 Staffing Indicators. Local conditions determine staffing levels. Baseline workload and funding are the dominant factors. However, there are some guidelines for setting approximate staffing levels in the facilities maintenance organization. Table 3-1 provides several indicators. Other staffing standards may be available through consultation with the human resources (personnel) department.

3.6 CUSTOMER RELATIONS

Everyone who works at or uses Field Installation facilities is a customer of the facilities maintenance organization. Some are direct customers, requesting and receiving specific services such as Trouble Calls or Service Requests. Others are indirect customers, using the facilities and collateral equipment such as heating, ventilating and air conditioning (HVAC) systems maintained by the facilities maintenance organization. Facilities maintenance, which provides institutional as well as program support, plays a major role in keeping these customers satisfied. This does not occur automatically. Customer relations should be a primary consideration in all facilities maintenance decisions. Facilities maintenance may be the key factor in developing and maintaining the profes-

STAFFING FACTOR RANGES

<u>POSITION</u>	<u>STAFFING RANGE</u>
Planner & Estimator (P&E), General	Each P&E hour generates about 25 hours of shop direct labor. See specific ranges by craft below.
P&E, Elec/Mech	1 per 12-18 craftsmen
P&E, PM and other recurring work	1 per 25-36 craftsmen
P&E, Building Trades	1 per 20-30 craftsmen
P&E, Grounds, etc.	1 per 40-60 workers
Inspector, Facilities	1 per 800,000 sf
Craftsmen	Annual payroll about 2% of facilities current replacement value (CRV).
Contract inspection for support services contracts for facilities maintenance.	Payroll about 3%-6% of contract value.

Table 3-1. Staffing Factor Ranges

sional reputation of Field Installation institutional managers.

3.6.1 FUNDING SOURCES

The facilities maintenance organization may find that a significant portion of its work is customer funded. This is especially the case with Service Requests and work directly supporting R&D programs. In establishing the organizational structure, the variability, time-phasing, and duration of customer-funded work should be considered. Provision should be made for estimating and

managing customer-funded work. Where the level of customer-funded work is variable or cyclical, use of contracts or temporary workers may be desirable.

3.6.2 MISSIONS

The facilities maintenance organization should understand the mission of each of its customers. This will lead to better resource allocation decisions, enable the organization to meet each customer's needs, and improve the organization's credibility in dealing with its customers.

3.6.3 MEMORANDA OF UNDERSTANDING (MOU)

MOU's and other formalized agreements spell out support agreements between organizations and agencies. MOU's may cover agreements between the facilities maintenance organization and other Field Installation departments, other Federal agencies, or local governments. Typically, MOU's outline details of services provided and funding responsibilities. It is possible for a Field Installation to be both a receiver of services from, and a provider of services to, another organization. The services may be on a reimbursable or non-reimbursable basis. Examples include provision of utilities, shared use of operational facilities such as runways, provision of fire protection services, and maintenance of special facilities such as aviation fueling systems.

MOU's can offer significant advantages through better use of facilities and avoided duplication of effort. The facilities maintenance organization should be alert for opportunities to use MOU's. Where services are available under an MOU, the facilities maintenance organization need not dedicate organizational resources to provide the service. The increased scope of the combined service may make it possible for the provider to perform the service at reduced unit cost to all customers by realizing economies of scale. An assessment of the impact of MOU's should be made while developing Annual Work Plans.

3.6.4 CUSTOMER LIAISON

An efficient customer liaison program is essential to effective facilities maintenance. Good customer liaison can provide early warning of changes in workload and identify

potential problems. It facilitates orderly workload planning by the facilities maintenance organization and its customers. A customer liaison representative should work with each customer. He should participate in the development of MOU's, Annual Work Plans, funding plans, and in the day-to-day support of the customer. However, every member of the facilities maintenance organization is an ambassador for the organization and should be sensitive to each customer's needs and perceptions.

The reputation of the facilities maintenance organization is built as much on perception as on performance. An effective facilities maintenance program has low visibility; usually customers are only aware of problems. A positive image of the facilities maintenance organization is created by proactive communications, by keeping the customer informed about the status of his work, responding quickly to his requests, informing him in advance about the cost of his work, and reflecting the costs accurately in reimbursable billings and reports.

3.7 INTERFACES WITH OTHER SUPPORT ORGANIZATIONS

Facilities and equipment maintenance program effectiveness often depends on the support provided by other Field Installation organizations. For example, the Comptroller may prepare budgets and allocate funds, the Human Resources Office may control staffing, the Procurement Office may handle requests for material, and the Administrative Office may handle reproduction and correspondence services. Responsibility for facilities planning and engineering, including major facilities and equipment acquisition, may rest with a separate organization, such as Facilities Engineering. Essential services

such as utilities may be purchased commercially or provided by a separate government or host activity. The facilities maintenance organization should maintain close communication and cooperation with other supporting organizations, working together to plan and manage the workload.

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CHAPTER 4. ANNUAL WORK PLAN (AWP)

4.1 INTRODUCTION

This Chapter:

- Defines the elements of an Annual Work Plan (AWP)
- Discusses the information structure needed to identify facilities maintenance requirements for each AWP element
- Suggests procedures for compiling that information and using it to construct each AWP element
- Describes a typical Field Installation-wide format for submitting annual facilities maintenance requirements

4.2 CONTENT

Figure 4-1 shows the elements comprising a facilities maintenance AWP. Each element can be developed and used as a separate entity. In Figure 4-1 Preventive Maintenance (PM) and Predictive Testing & Inspection (PT&I) are separated by a broken line because they are closely related. The same is true of Repairs and Trouble Calls. Cumulatively, the elements define the total facilities maintenance program planned at a Field Installation for a given year and the estimated cost in dollars and other resources; i.e., manpower, materials, and equipment.

The dollar limits for a work package in each facilities maintenance work element are shown in Table 1-2.

4.3 INFORMATION SOURCES

Preparing an AWP requires specific information. A facilities and collateral equipment inventory comprises the basic information needed. Such an inventory database should be augmented by a variety of files, including PM requirements, a continuous inspection program, and facilities history records.

4.3.1 INVENTORY FILES

The scope of an inventory database varies widely, starting with a simple list of individual buildings and structures, each identified by a numbering or coding system. An inventory database that defines collateral equipment should supplement this basic facilities list. A more complete database could include both equipment and individual components comprising the buildings, utility systems, grounds, pavement, and other structures. A complete inventory database could be structured to include each discrete maintainable facility component; i.e., one for which maintenance requirements can be predefined (such as PGM or PM), or for which irregular maintenance requirements can be identified by a continuous inspection program.

4.3.2 PREVENTIVE MAINTENANCE DATABASE

A PM program is one element of an overall AWP for an installation. The PM database should include the following:

- Inventory of maintainable items.

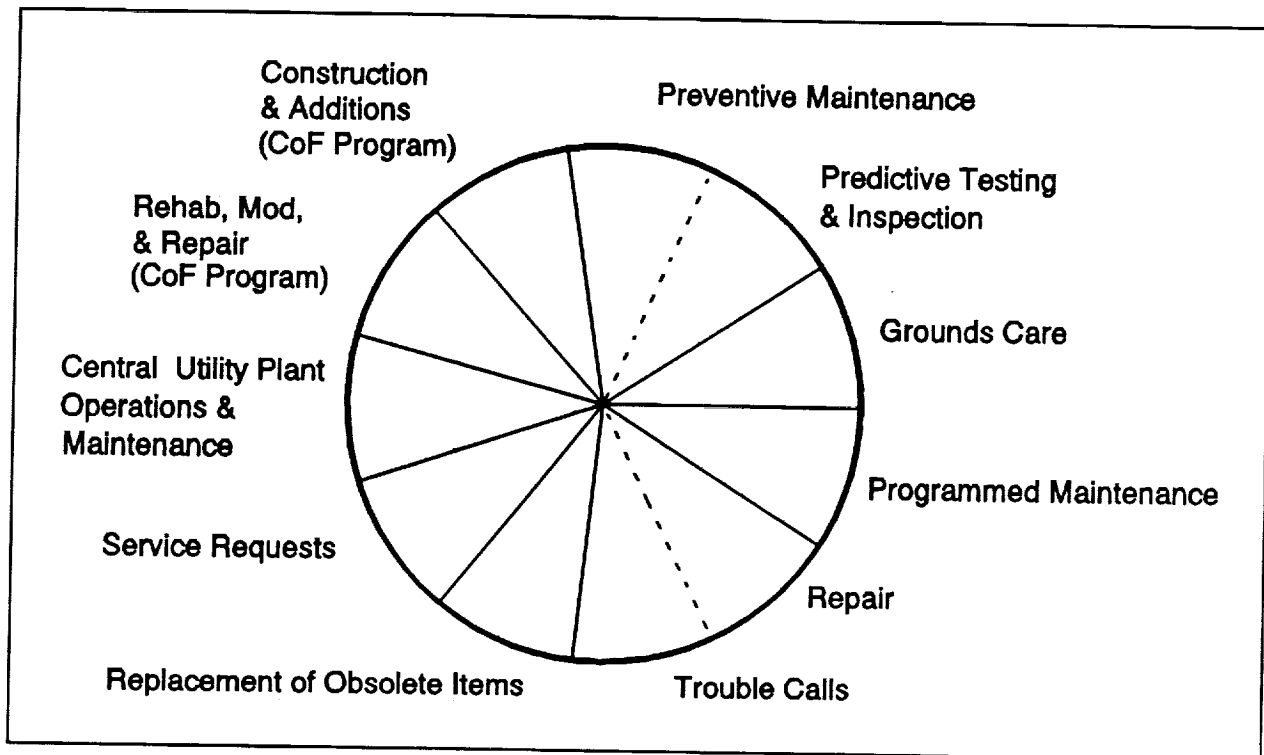


Figure 4-1. Facilities Maintenance Annual Work Plan

- Specific maintenance tasks to be performed on each maintainable item of unattended, maintainable collateral equipment. These are periodic tasks for accomplishment on equipment items to keep them in good operating condition and to prolong their service lives.
- The parameter (e.g., maximum allowable pressure drop, maximum allowable bearing temperature or recommended time interval between PM service) defining when each PM task should be performed.
- The estimated resources required to perform each PM task in terms of manhours (by craft), materials, tools, and equipment.
- Specific instructions for obtaining condition assessment information as part of the maintainable collateral equipment PM. The information to

be recorded includes the condition of the overall item of equipment and, in some cases, of a part or subsystem of the equipment item. Instructions should also define a procedure for describing and documenting the results of the condition assessment.

4.3.3 FACILITIES/EQUIPMENT HISTORY DATABASE

Concurrent recording within the historical database of the condition of the PM-ed items is one important product of the PM program. A continuous inspection program should be established to provide a basis for determining PGM and repair requirements for those items such as roofs, doors, walls, and windows that are not included in the PM program.

Once the facilities inventory is in place, it must be continuously updated to keep the inventory current and to maintain a detailed record of facilities condition. This is accomplished using the PM and continuous inspection programs. Historical files are a repository for all of the information on inventory items that is useful in preparing an AWP. These files must be structured carefully so that they include all necessary data, including:

- Records of PM work accomplished; i.e., identifying PM work done, dates of PM performance, and costs in manhours and dollars.
- Records of PGM and Repair work accomplished; i.e., identifying PGM and Repair work done, dates of work performance, and costs in manhours and dollars.
- Condition assessment information developed during maintenance work.
- Condition assessment information developed during the continuous inspection program.
- Designation of candidate items for ROI.

4.4 STRUCTURE AND INTERRELATIONSHIP OF AWP ELEMENTS

4.4.1 PREVENTIVE MAINTENANCE (PM)

The PM requirements for maintainable collateral equipment items are defined using manufacturers' recommendations, historical information, the technical expertise and experience of the maintenance staff, and other sources. After defining the PM requirements, sum those requirements and their estimated costs in manhours and dol-

lars for a fiscal year. (Define or estimate cycle periods for each PM task.) These totals define the level of effort, i.e., manpower and funds, required to accomplish the unconstrained PM program. Evaluate those figures in terms of projected facilities maintenance funding and manpower levels and the estimated requirements for the other elements of the AWP. Such an evaluation is used to establish target resource allocations for the PM program on an annual basis during the 5-year planning period.

4.4.2 PREDICTIVE TESTING & INSPECTION (PT&I)

PT&I, sometimes called condition monitoring, involves determining or monitoring potential problems or variance conditions before operational problems arise. This sensing often involves using specialized equipment, either fixed or portable, and inspection or monitoring procedures. Inspection involves gathering condition data on potential sources of failure. A PT&I program provides some of the condition data needed to carry on other elements, e.g., PGM or Repair, of an AWP. Because it entails a dedicated effort drawing upon facilities resources, PT&I is an element of the AWP. Predictive testing can greatly impact an AWP because it extends the reach of the inspection program. For example, vibration analysis of a generator might be the basis for either accelerating or deferring a scheduled major overhaul, or infrared testing of a roof might indicate the need for small repairs now and avert a major CoF Repair project in the future.

4.4.3 GROUNDS CARE

Grounds care normally is accomplished under a standing work order for in-house forces or a contract with a relatively constant level of effort during the growing season. The level of effort can be predicted with a high degree of accuracy.

4.4.4 PROGRAMMED MAINTENANCE (PGM)

PGM work refers to recurring work performed at longer than 1 year cycles. It involves predefined, specific work tasks. PGM work schedules often are determined on the basis of actual conditions, rather than by fixed intervals. Because of this reliance on condition data to schedule PGM tasks, a continuous inspection program is required. The alternative to establishing and maintaining a facility condition program is a piecemeal approach where requirements are identified by facility occupants or by facility maintenance personnel through operational considerations or chance observations.

Condition codes should be established and recorded in the facilities history database for each facility maintenance function applicable to each inventory item. They should be structured to trigger the identification of candidate PGM work when a certain condition level is recorded through the inspection program.

Candidate PGM work can be costed and evaluated for programming in a particular annual program on the basis of projected funding levels. It is a case of analyzing all of the PGM requirements against other AWP requirements and allocating resources based on priorities. Work may be accomplished by civil service employees, incum-

bent support service contractors (if the work is determined to be within the scope of the contract), or by a separate, new contract.

4.4.5 REPAIR

Repair implies urgency because it involves fixing something broken or failing. It is work planned and executed as a single function; e.g., replacing a boiler or repairing leaking tanks. Non-CoF Repair work must be within the Field Installation Director's funding authority.

The PM program, the continuous inspection program, users/occupants, or facility maintenance personnel can identify Repair requirements. A clear distinction cannot always be made between PGM and Repair. For example, roof replacement, pavement sealing, and painting of entire structures are considered PGM; but replacing only a portion of a roof, repairing potholes, or spot painting are considered Repair. Similarly, replacing a lengthy section of sewer line because of general deterioration is PGM; but replacing short lengths of sewer line at various times and locations because of localized failures is Repair. A general criterion is that Repair usually involves Repair of portions of an overall facility or system, whereas PGM involves restoration of the entire system at the end of its anticipated life cycle.

A clear distinction between Repair and Trouble Calls is more difficult to make. In general, Trouble Calls are generated by phone calls requiring preparation of a Trouble Call Ticket and are not fully planned and estimated. If the Trouble Call work escalates above about \$2,000, normally a fully planned and estimated work order is prepared when the emergency condition is

stabilized, and the work continues as a Non-CoF Repair with a threshold of \$200,000 or as a CoF funded Repair project if the estimated cost exceeds \$200,000.

Local replacement criteria should be established. For example, an item should be replaced rather than repaired if the Repair cost exceeds 50 percent of the replacement cost.

4.4.6 TROUBLE CALLS

Trouble Calls address items that break or are damaged unexpectedly. While a facilities maintenance manager can use experience to estimate the level of Trouble Call effort adequate for the AWP, he should adjust the estimate upward to reflect inflation and physical plant additions and downward to reflect improvements in the maintenance program and decreases in the size of the physical plant.

4.4.7 REPLACEMENT OF OBSOLETE ITEMS (ROI)

ROI requirements are normally identified through a variety of sources; e.g., the breakdown of one of several of the same model pump may lead to the discovery that parts are no longer available for that pump; PM inspection reports may identify equipment items failing to meet new electrical code requirements; or manufacturer's data for a newly purchased pump may indicate that similar on-site pumps are no longer parts supportable. Equipment history files need to be structured and procedures established to recognize this type of information in the facilities maintenance system and flag the associated equipment item as an ROI candidate. The facilities maintenance manager can then list ROI candidates and evalu-

ate them for replacement on the basis of safety and operational impact.

4.4.8 SERVICE REQUESTS

Small Service Requests are often performed by the same shop that performs Trouble Call work. While Service Requests are non-maintenance work, small Service Requests are similar to small Trouble Calls in that they consist of the minor facilities support work to maintain routine installation operations. An analysis of the Trouble Calls accomplished and the Service Request records identifies the relative levels of effort allocated to each of these similar elements of the AWP. Normally, outside contractors perform work generated by large Service Requests. Service Request work includes facilities construction and additions costing less than the CoF \$200,000 threshold.

4.4.9 CENTRAL UTILITY PLANT O&M

Central utility plant operations and maintenance is normally accomplished under a standing work order because it requires a nearly constant level of effort (depending upon the season).

4.4.10 REHABILITATION, MODIFICATION, REPAIR, CONSTRUCTION AND ADDITIONS

Rehabilitation, modification, repair, construction, and additions are CoF categories described in NHB 8820.2, *Facility Project Implementation Handbook*, and NMI 7330.1, *Delegation of Authority - Approval Authorities for Facility Projects*, and the NASA *Financial Management Manual*, *Agency-wide Coding Structure*, FMM 9100.

4.5 FIVE-YEAR FACILITIES MAINTENANCE PLAN

Facilities maintenance organizations in both the public and private sectors widely accept the concept of an AWP as an aid for both the budgetary and the work execution processes. The AWP can assist the facilities maintenance manager in establishing goals within projected resources and in planning to meet those goals. However, developing an AWP and the process by which it is developed are subject to wide interpretation.

Facilities maintenance managers generally agree that an AWP should evolve from a multi-year plan derived from a complete and continuously updated list of facilities requirements. Such multi-year planning promotes achieving long-range goals and consistent direction in facilities maintenance management. Facilities maintenance managers typically maintain a moving, 5-year program of annual work plans in the form of a Five-year Facilities Maintenance Plan. Such a plan is discussed in the following paragraphs in relation to the AWP.

4.6 FACILITIES WORK REQUIREMENTS

4.6.1 TOTAL REQUIREMENTS

An elusive goal of facilities maintenance managers is to develop and maintain a system to define a complete, unconstrained list of all existing and predictable facilities maintenance work requirements. Such a list should include not only the backlog of deferred facilities maintenance, but also current and continuing requirements for PM, PT&I, Grounds Care, PGM, Repair, Trouble Calls, ROI, and projections for new work to respond to evolving organizational

and facilities maintenance requirements. Such a database could then be the basis for defining the Five-year Facilities Maintenance Plan and the AWP, because the database should contain all potential facilities maintenance work. Thus, it should be the task of the facilities maintenance manager to use the database to construct that balanced AWP that most effectively responds to conflicting priorities within programmed resources.

4.6.2 BACKLOG OF DEFERRED FACILITIES MAINTENANCE

The backlog of deferred facilities maintenance is the total of essential but unfunded facilities maintenance work necessary to bring Field Installations to the required facilities maintenance standards. It is work that should be accomplished during a particular year but cannot be accomplished within projected resources. It does not include construction, additions, or other CoF work, but it does include unfunded CoF Repair projects.

The backlog is an excellent indicator of the condition of Field Installation facilities and collateral equipment. It reflects the cumulative effects of underfunding facilities maintenance and repair. Review of backlog trends and comparison of the backlog with the Current Replacement Value (CRV) and facilities maintenance funding provide indications of the adequacy of the resources devoted to facilities maintenance.

In order to be credible, the backlog should be calculated on the basis of a condition assessment of all facilities as follows:

- a. All current maintenance deficiencies should be identified and costed based

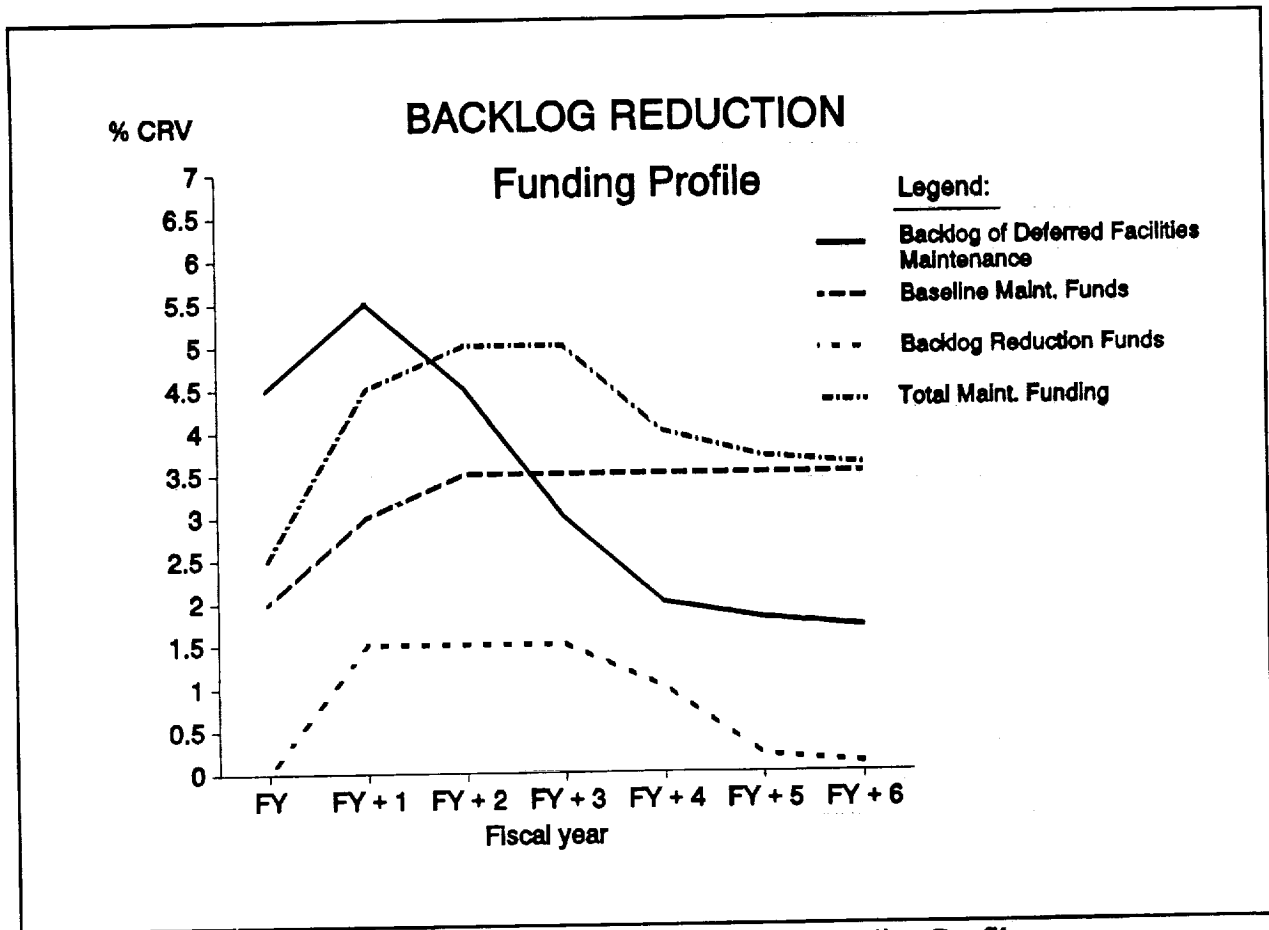


Figure 4-2. Typical Backlog Reduction Funding Profile

on a current facilities condition assessment.

- b. Deficiencies that will be corrected as part of the current year AWP should be subtracted.

The annual facilities maintenance budget should average 2 percent-4 percent of the CRV. However, this rule-of-thumb applies only when the facilities have reached a steady-state maintenance condition; i.e., when the backlog has been reduced to an acceptable level. What an acceptable level is depends upon the nature of the backlog and the mission of the Field Installation. For example, a large backlog for interior paint-

ing may be acceptable, while a large backlog of roof repairs may portend serious problems and should be reduced quickly.

Figure 4-2 illustrates the relationship between the backlog and annual maintenance funding levels as a percentage of CRV. It shows also a method of backlog reduction. For illustrative purposes only, Figure 4-2 assumes that 3.5 percent is the optimum steady-state maintenance funding level and that a backlog under 2 percent of CRV is acceptable. In this example, annual maintenance funding initially averages 2 percent of CRV, and the backlog is increasing each year. Then baseline annual maintenance funding increases to 3.5 percent over a two

year period, and additional funding is programmed for backlog reduction over a six year period. As the backlog is reduced to below 2 percent of CRV, special funding for backlog reduction decreases, but baseline maintenance funding remains at 3.5 percent. If the backlog begins to increase, maintenance funding should be increased to again reduce the backlog below 2 percent of CRV.

4.6.3 WORK ELEMENT RELATIONSHIPS

There are relationships among the facilities maintenance work elements that indicate the strengths and weaknesses of a facilities maintenance program. Table 4-1 shows typical ranges of effort for the principal work elements at a large physical plant of diverse age and complexity.

The percentages in Table 4-1 apply to the total facilities maintenance effort. The percentage ranges are guides only. For example, if Repairs exceed 20 percent by a significant amount, it may indicate that more effort should be put into PM, PT&I, and PGM. Likewise, if Trouble Calls exceed 10 percent, it may indicate that PM and PT&I effort should be increased. The greatest effort, 50-60 percent, should be applied to PM, PT&I and PGM. The limit on Service Request work is suggested only because of the potential for a large amount of Service Request work to detract from the maintenance effort.

The ranges in Table 4-1 are recommended as a basis for self-evaluation until each Field Installation accumulates sufficient data to reflect its unique situation. Thereafter, analysis should be based on the relationships appropriate to the Field Installation.

Two of the work elements do not appear in Table 4-1, Central Utility Plant Maintenance and Operations and Grounds Care. Both depend on local circumstances and vary too widely to estimate a meaningful range.

There are also useful ratios that can be used to assess the facilities maintenance program. These are shown in Table 4-1. Trends in these three ratios indicate facilities maintenance performance.

Absolute values cannot be assigned to these ratios. However, facilities maintenance managers should track the ratios and strive to maintain a downward trend.

In the case of Ratio 1, the amount of CoF (Construction and Additions) and SR, both new work, is not controlled by the facilities maintenance organization. However, if the ratio is high and increasing, plant degradation may result. New work increases the CRV and the maintenance workload. Maintenance funds should increase proportionately in order to maintain the desired 2-4 percent of CRV maintenance funding level.

With respect to Ratio 2, the numerator can be controlled only within narrow limits. Also, the numerator is oriented toward correcting things that are broken. The opposite is true for the denominator. Management decides how much effort to expend on the denominator which is preventive in nature, because it minimizes future failures. There is an inverse correlation and a multiplier effect between the denominator and the numerator. As the denominator decreases, the numerator usually increases much faster. For example, failure to perform PM on a piece of equipment or system usually results in much more costly Repair later on. A small change in the denominator should,

SUGGESTED WORK PERCENTAGES BY FACILITIES MAINTENANCE ELEMENT

WORK ELEMENT*	AVERAGE RANGE AS PERCENT OF TOTAL WORK EFFORT
Preventive Maintenance (PM)	15-18%
Predictive Testing & Inspection (PT&I)	10-12%
Programmed Maintenance (PGM)	25-30%
Repair	15-20%
Trouble Calls (TC)	05-10%
Replacement of Obsolete Items (ROI)	15-20%
Service Requests (SR)	0-05%
<hr/>	
Total	100%

*Excludes Central Utility Plant Operations & Maintenance, Grounds Care, indirect labor and overhead (supervision, continuous inspection, P&E, etc.)

RATIOS THAT INDICATE FACILITIES MAINTENANCE PERFORMANCE

$$\begin{aligned}
 \text{Ratio 1: } & \frac{\text{New Work}}{\text{Maintenance}} = \frac{\text{CoF (Construction \& Additions) + SR}}{\text{PM + PT\&I + PGM + REPAIRS + ROI}} \\
 \text{Ratio 2: } & \frac{\text{Uncontrolled Work (Corrective)}}{\text{Controlled Work (Preventive)}} = \frac{\text{REPAIRS + TC}}{\text{PM + PT\&I + PGM + ROI}} \\
 \text{Ratio 3: } & \frac{\text{Backlog of Deferred Facilities Maintenance}}{\text{CRV}}
 \end{aligned}$$

Table 4-1. Suggested Work Percentages and Indicators

over time, cause a much larger opposite change in the numerator.

For Ratio 3, the trend should always be downward, toward the NASA goal of eventually eliminating the backlog.

As a general trend rule, the percent of work authorized by work order should increase, the percent of PM work should increase, and the percent of unscheduled work should decrease.

4.7 RESOURCES

While most AWP preparation focuses on requirements definition and matching those requirements to projected funding levels, the personnel resources required to execute an AWP are also a critical aspect of the planning process. The timely mobilization of personnel with the requisite skills is a complex task. Generally, there are three categories of personnel available to execute the AWP: civil service personnel; support services contractors; and outside contractors.

As the Five-year Facilities Maintenance Plan evolves, the facilities maintenance manager should explore alternatives for matching projected work with personnel resources. The earlier he can define the work requirements, the more efficient he can be in mobilizing those resources. For example, if the Five-year Facilities Maintenance Plan indicates that electrical work will exceed current shop resources in three years, he can take steps early to adjust the support services contract or identify specific work to be performed by outside contractors.

4.8 LOCAL ANNUAL BUDGET CALL

A practical approach to compiling the best current definition of overall facilities maintenance requirements is an annual budget call. The call should require all organizational elements with facilities maintenance responsibilities to identify work projected for accomplishment during and beyond the budget year. Input from all cognizant sources is critical to preparing an overall AWP that responds most accurately to Field Installation needs. Structure the call to obtain feedback that addresses both work requirements and the resources available to accomplish the work.

The following paragraphs present simplified samples of installation-wide annual calls for facilities maintenance requirements. The calls should go to organizational elements with facilities maintenance responsibilities, with submittals compiled into one overall AWP. Calls should include guidelines on goals and priorities. Also, calls should include definitions of the elements of facilities maintenance applicable to an AWP to promote uniformity among the submittals.

4.8.1 INFORMATION REQUIREMENTS

Each call letter should request submittal of unconstrained requirements spread over 5 fiscal years, the baseline first year being the current year. Submittal formats should require identifying funding sources, e.g., R&PM, R&D, SFCDC, CoF, or reimbursable (if known), providing a justification for changes from one year to another (unless reimbursable), and stating the impact if funds are not provided in the year requested.

4.8.2 SUGGESTED SUBMITTAL FORMATS

4.8.2.1 Skill Mix In Hours Format. Format Number 1 (Figure 4-3) can be used for separately submitting each of the following work categories:

- Preventive Maintenance.
- Predictive Testing & Inspection.
- Trouble Calls.
- Service Requests.
- Grounds Care.
- Central Utility Plant Operations & Maintenance.

4.8.2.2 Project Format. Format Number 2 (Figure 4-4) can be used for projects planned for accomplishment in each of the following work categories:

- Programmed Maintenance.
- Repair.
- Replacement of Obsolete Items.
- New Work (minor construction & additions, rehabilitation & modifications).

Format Number 3 (Figure 4-5) can be used to provide justification data for each project item listed in Format Number 2.

4.8.2.3 Sample Submittals. Figures 4-6 through 4-8 are examples of submittals for each of the three formats.

FORMAT NO. 1

(Originator)

(Date)

WORK ELEMENT: _____

Facility No. _____

Funding Source: _____ (\$000)

Personnel: _____

Craft

	<u>FY1</u> <u>No.</u> <u>\$</u>	<u>FY2</u> <u>No.</u> <u>\$</u>	<u>FY3</u> <u>No.</u> <u>\$</u>	<u>FY4</u> <u>No.</u> <u>\$</u>	<u>FY5</u> <u>No.</u> <u>\$</u>
1.					
2.					
3.					
4.					

Materials

Totals

Notes:

1. Personnel refers to either Civil Service (CS) or support services contractor (SSC); provide separate sheets for each labor source.
2. Cost figures should be fully burdened.
3. Provide accompanying written justification and impact if increases from the base (FY XX) year are not provided in the year indicated.
4. Estimated material costs to be provided by facility; do not break down by craft.

Figure 4-3. Skill Mix In Hours, Format Number 1

FORMAT NO. 2

(Originator)

(Date)

WORK ELEMENT:

Facility No.

Funding Source:

(\$000)

Project

FY1

FY2

FY3

FY4

FY5 Mode*

- * Projected method of accomplishment: CS for Civil Service, SSC for support services contractor; C for outside contractor.

Figure 4-4. Projects, Format Number 2

FORMAT NO. 3

(Originator)

(Date)

FY__ FACILITIES PROJECT

PROJECT TITLE: _____

PROJECT ID: _____

ESTIMATED COST: \$__ (\$000)

Description:

Cause:

Justification:

Impact if Not Funded:

Figure 4-5. Individual Project, Format Number 3

FORMAT NO. 1

Earth Probes Program
(Originator)

16 Mar 91
(Date)

WORK ELEMENT: Preventive Maintenance

Facility No. N-235

Funding Source: R&PM (\$000)

Personnel: SC

<u>Craft</u>	<u>FY91</u>	<u>FY92</u>	<u>FY93</u>	<u>FY94</u>	<u>FY95</u>
	<u>No.</u> <u>\$</u>	<u>No.</u> <u>\$</u>	<u>No.</u> <u>\$</u>	<u>No.</u> <u>\$</u>	<u>No.</u> <u>\$</u>
1. Electrician	3 119	3 125	4 175	4 184	4 193
2. Mechanic	2 85	3 134	3 140	3 147	3 155
3.					
4.					
<u>Materials</u>	15	16	17	18	19
Totals	5 219	6 275	7 332	7 349	7 367

Notes:

1. Personnel refers to either Civil Service (CS) or support services contractor (SSC); provide separate sheets for each labor source.
2. Cost figures should be fully burdened.
3. Provide accompanying written justification and impact if increases from the base (FY XX) year are not provided in the year indicated.
4. Estimated material costs to be provided by facility; do not break down by craft.

Figure 4-6. Sample of Skill Mix In Hours Submission

FORMAT NO. 2

Physical Climate and Hydrologic System Program
(Originator)

12 Jan 91
(Date)

WORK ELEMENT: Programmed Maintenance

Facility No. N-241, 14' Wind Tunnel

Funding Source: R&D (\$000)

<u>Project</u>	<u>FY91</u>	<u>FY92</u>	<u>FY93</u>	<u>FY94</u>	<u>FY95</u>	<u>Mode*</u>
Replace Inflatable Seals	100					SSC
Paint Test Chambers	200					C
Replace Drier Insulation			150			SSC

- * Projected method of accomplishment: CS for Civil Service; SSC for support services contractor; C for outside contractor.

Figure 4-7. Sample of Project Submission

FORMAT NO. 3

Advanced Communications Satellite Program
(Originator)

10 Jan 91
(Date)

FY-91 FACILITIES PROJECT

PROJECT TITLE: Replace Inflatable Seals, 14' Wind Tunnel

PROJECT ID: 2196

ESTIMATED COST (\$000): 13

Description: Inspect, repair, and replace the inflatable seals in the 14' Wind Tunnel. These seals are in the expansion joints, various access doors, and the flow diversion valves of the supersonic legs of the tunnel.

Cause: The seals are beyond their useful life (most are original equipment) and are in need of replacement. Replacement requirement reported in August 1990 inspection report.

Justification: Seals must be repaired because failure adversely affects data quality and productivity. Difficulty is being experienced in maintaining the low level of specific humidity which is causing loss of productivity. Leaks in the internal seals in the nozzle area of supersonic facilities affect the flow quality in the test section and those which seal against the outside environment allow moisture to enter the tunnel. The moisture must be eliminated by the time-consuming and expensive process of purging the tunnel.

Impact if Not Funded: At least 300 manhours per year over normal operational workload will be required to keep the wind tunnel functioning.

Figure 4-8. Sample of Facilities Project

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CHAPTER 5. WORK CONTROL SYSTEM

5.1 INTRODUCTION

The work control system is the central feature of facilities maintenance management. It comprises the tools, techniques, checks, management controls, and documentation needed for effectively managing the work-flow. This chapter presents the key functions of a work control system. It covers the implementation of the system of controls in the model presented in Chapter 3 (Appendix C, reference 3).

The work control system provides for control and management of the facilities maintenance workload from inception through completion to the ultimate disposal of the facility or equipment. Figure 5-1 shows the several distinct stages in the work generation, control, and performance cycle. As shown in the figure, work control includes "Work Reception & Tracking" and "Work Order Preparation."

In this chapter the term shops is used to refer to the facilities maintenance work force, including both civil service and support services contract employees.

5.2 WORK GENERATION

Work generation is the process of identifying and documenting facilities maintenance deficiencies and requirements. The following paragraphs describe the primary means of work generation. They are:

- Inspection programs.
- Facilities maintenance work.
- Trouble Calls.
- Service Requests.

- Other requests.
- Annual Work Plan.

5.2.1 INSPECTION PROGRAMS

In an effective facilities maintenance program most of the facilities maintenance work other than Preventive Maintenance (PM) and operator maintenance is generated from inspections and predictive testing conducted by or under the auspices of the facilities maintenance organization. Chapter 7 describes inspections and facilities maintenance standards. The principal types of inspections are:

- Preventive Maintenance Inspections.
- Predictive Testing and Inspection. (PT&I).
- Continuous Inspections.
- Operator Inspections.
- Specialized Inspections.

5.2.2 FACILITIES MAINTENANCE WORK

A significant portion of the facilities maintenance workload results from ownership and inventory. This is largely repetitive and recurring work that can be predicted based on knowledge of the maintainable facilities and collateral equipment. Examples include Preventive Maintenance (PM), Programmed Maintenance (PGM), and recurring work such as grass cutting and relamping. The scope and extent of these kinds of work are typically defined when a facility is acquired.

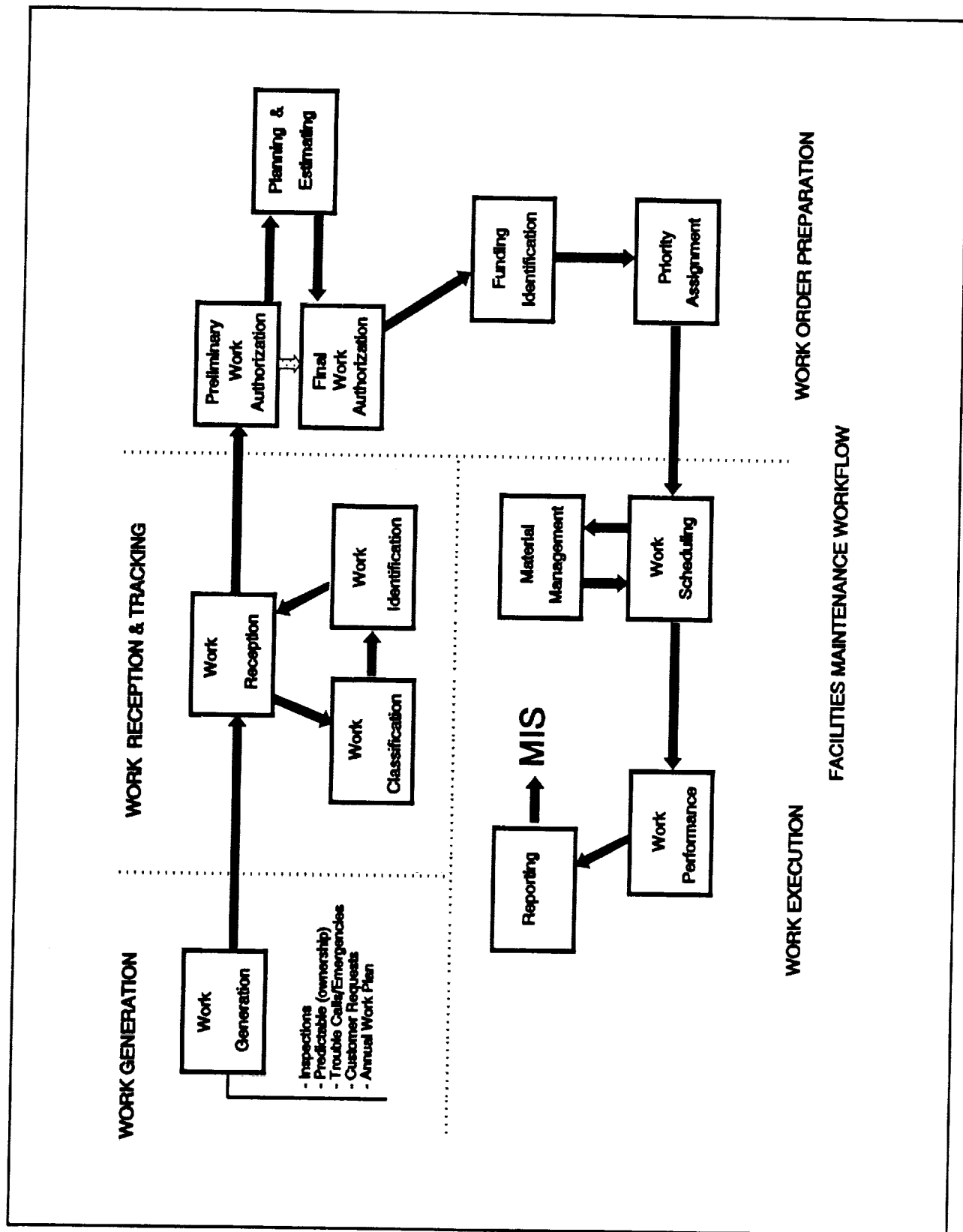


Figure 5-1. Stages in Work Generation, Control, and Performance

5.2.3 TROUBLE CALLS

Normally, Trouble Calls are reported by telephone to the work reception desk. Operating the work reception desk is one of the functions performed by the work control center (see paragraph 5.3). Although Trouble Calls can be placed by anyone, normal practice is to designate one individual in each major building or organization as the point of contact for placing Trouble Calls. This minimizes duplication of effort and simplifies work tracking. Emergency calls are accepted from anyone. In recognition of the limited scope of work covered by a Trouble Call, it is normally not estimated or scheduled, but it is tracked for execution. Trouble Call work is typically issued to the shops on a Trouble Call ticket and tracked by the ticket identification number.

5.2.4 SERVICE REQUESTS

A Service Request is new work requested by a customer. It may be either a small job that does not require planning and estimating or a large job that requires planning, estimating, and scheduling. Normally, Service Requests are customer-funded.

5.2.5 OTHER REQUESTS

Other requests for facilities maintenance work include work not identified as part of the facilities maintenance inspection program. Examples are maintenance deficiencies found by a fire safety inspection or a request for Repairs for a problem that has occurred since the last facilities maintenance inspection. These requests should be separately tracked to provide status and execution feedback to the requestor and to monitor the effectiveness of the facilities maintenance inspection program.

5.2.6 ANNUAL WORK PLAN (AWP)

The AWP (see Chapter 4) identifies all facilities maintenance work planned for the year.

5.2.7 DOCUMENTATION

5.2.7.1 Trouble Calls. Appendix D, Figure D-1, is a sample format with data element definitions for a Trouble Call ticket that can be used to document and track Trouble Calls. This format should be automated to permit entering the request at a computer terminal and automatically issuing the work order to the shops.

5.2.7.2 Request for Facilities Maintenance Services. Figure D-2 is a typical form for submitting customer-generated requests for facilities maintenance work and work identified within the facilities maintenance organization. The form provides for recording the essential information for managing the work and for processing the work request through the facilities maintenance organization. The form should be automated for submitting, recording, and processing the request.

5.2.7.3 Inspections. Appendix G contains a sample form to document inspections as part of a condition assessment program.

5.3 WORK CONTROL CENTER

The Work Control Center (WCC) is the nerve center for facilities maintenance management. It is the central location for work reception, tracking, and management.

The work control function may be assigned to any organizational element in the facilities maintenance organization; however, it is

suggested that it be assigned directly under the facilities maintenance manager, independent of the shops or planning and estimating (P&E) functions. It may be staffed and operated by civil service or contract employees; however, if operated by a support services contractor, care must be taken to ensure that the contract specifies detailed performance requirements and that an effective quality assurance program is maintained. In addition, the contract should provide for direct Government access to the Computerized Maintenance Management System (CMMS) facilities maintenance management database and report generators for purposes of queries on work status, analysis of work statistics, and facilities maintenance management surveillance. Providing CMMS terminals at designated Government offices will enable the Government to accomplish this.

5.4 WORK RECEPTION

The major work reception functions are:

- Receiving and logging work generated from all sources.
- Assigning initial classifications to the work.
- Tracking the work as it progresses through the facilities maintenance system.
- Maintaining records on requested work, inspections, jobs in progress, and completed work.

5.5 WORK TRACKING SYSTEM

The work tracking system enables work tracking from the time it enters the facilities maintenance system until it is either disapproved or completed. It involves:

- Classifying the work into groupings of management interest.
- Assigning unique identifiers to each item of work
- Monitoring the work status and the work progress through the facilities maintenance system.
- Reporting that status.

5.6 WORK CLASSIFICATION

Work classification provides the ability to subject work to the proper levels of review and control and to perform management analyses of the workload. Suggested categories for work classification are discussed below. These categories extend beyond the minimum required for financial accounting and budgeting and provide additional detail for managing the facilities maintenance organization. They are important for managing the workload and understanding where resources are expended. The use of automated systems permits ready accumulation and analysis of the data. Field Installations may wish to add additional classifications for local use. The following are some methods of classifying work:

- Funds type.
- Approval level.
- Work type.
- Special interest.
- Size.
- Method of accomplishment.
- Repetitive nature.

Each is discussed below.

5.6.1 FUNDS TYPE

Funds type describes whether the work is reimbursable or non-reimbursable. If reimbursable, it identifies the customer, and, if

non-reimbursable, it identifies the appropriation and project or program. Funds type is not the same as funds source because fund source does not identify the specific reimbursable customer, program, or project.

5.6.2 APPROVAL LEVEL

This identifies who has the authority to approve the work. The approval level is primarily a function of the work size and type.

5.6.3 WORK TYPE

Work type identifies which of the following standard work elements applies:

- PM.
- PT&I.
- Grounds Care.
- PGM.
- Repair.
- Trouble Calls.
- Replacement of Obsolete Items (ROI).
- Service Request.
- Central Utility Plant O&M.
- Rework.

Work type is useful in analyzing work element relationships as described in paragraph 4.6.3. Rework is work accomplished to correct previous work that was rejected or faulty. It is important to know how much rework is being done and what is causing it.

5.6.4 SPECIAL INTEREST

This classification identifies and permits the accumulation of statistics on work performed in support of specific or special interest programs, initiatives, or work not

otherwise accounted for by special funding programs. Examples include:

- Energy conservation
- Safety
- Environmental compliance
- Handicapped access
- Community relations

5.6.5 SIZE

Work size, grouped in dollar or level-of-effort ranges, indicates the amount of management effort required and is useful in determining the type of funds used, the approval level, and the method of accomplishment.

5.6.6 METHOD OF ACCOMPLISHMENT

The method of accomplishment identifies whether the work will be accomplished by civil service employees, incumbent support service contractors (if the work is determined to be within the contract scope), or by a separate, new contract.

5.6.7 REPETITIVE NATURE

Repetitive nature indicates whether the work is of a one-time nature and should be accomplished by a Trouble Call ticket, specific work order, or separate contract or whether it is repetitive and should be accomplished by a standing work order.

5.7 WORK ORDER IDENTIFICATION

Each work order is given a unique identifier (alpha-numeric). This identifier permits tracking the work order through its life cycle. The identification scheme should

meet the Field Installation's needs. Typical numbering systems include a number identifying the year, the fund source, and a sequential number. For example, the number 91-200408-0012 could represent (from right to left) the 12th work order issued under FMS code 20-04-08 in fiscal year 1991. Trouble Call tickets may use a separate numbering scheme.

5.8 WORK STATUS

Work status refers to the state of work progress in the facilities maintenance system as it proceeds from generation to completion. It includes the identification of actions completed, actions pending, responsible parties, and milestone dates. It is a key element in maintaining good customer relations by making it possible to provide responsive feedback to the customer. The CMMS should provide means for documenting and reviewing work status. A suggested way of accomplishing this is assigning status codes or milestone data to each item of work. Personnel with CMMS access can then examine the status information or the management information system can use it when preparing reports.

As a minimum, the CMMS should contain the estimated or actual start and completion dates and the responsible party for each of the following milestones in the facilities maintenance process:

- Work Reception (including classification and identification phases).
- Planning and Estimating.
- Final Authorization.
- Scheduling.
- Material Management .
- Work Performance.

Not all milestones are applicable to all work. For example, Trouble Calls would only track status information related to work reception and work performance. Requests for cost estimates only would not record data for final authorization, scheduling, material, or work performance. The shop load plan and master schedule typically contain material and work performance status information for scheduled work.

5.9 WORK ORDER PREPARATION

The work order is the document directing the shops to perform certain items of facilities maintenance work. Normally, P&E's prepare work orders. (An exception is the Trouble Call ticket discussed below.) The work order includes an estimate of the resources required to perform the job (man-hours by craft, materials, equipment, tools, and specialized support), the steps or tasks required to perform the job, documentation of coordination and outages, safety requirements, job priority, job accounting information, and any other information required by management and the shops to schedule, perform, and evaluate the work. Appendix D, Figure D-3, is a sample work order form.

For small jobs, typically less than 20 man-hours, the cost of detailed planning and estimating and scheduling may exceed the benefit. In these cases use of a Trouble Call ticket format is suggested. Appendix D, Figure D-1 is a sample Trouble Call ticket.

5.9.1 REVIEW, SCREENING, AND AUTHORIZATION

Work review, screening, and authorization is typically a two-step process. Requests for work receive an initial screening prior to job planning and estimating. The second step

provides final approval and release of the planned and estimated work order for scheduling. In the case of Trouble Calls and work on small jobs this may be accomplished in one step, within the decision authority of the work reception desk, bypassing planning and estimating. (This is symbolized by the lightly shaded arrow connecting the preliminary and final work authorization blocks in Figure 5-1.)

5.9.1.1 Preliminary Work Authorization. The preliminary screening determines if requested work should be accepted for continued processing, rejected, returned to the requestor for additional information, or given preliminary approval for detailed planning and estimating. For work of limited scope it may also serve as the final authorization.

5.9.1.2 Final Authorization. Once the work order is planned and estimated, it is forwarded for final authorization. The review process checks the work order to ensure that it is responsive; complies with applicable safety, health, environmental, and security standards; is within the scope of the Annual Work Plan; and is within funding and approval levels. This review normally takes place in the facilities maintenance organization; however, on complex or critical jobs, the customer should review the work order to check its technical adequacy.

When reviews are completed, the work order is authorized for execution by the appropriate approving official. (The approving official is determined by Field Installation policy. Common practice is to delegate work approval authority to permit routine and recurring work approval at the lowest responsible level in the facilities maintenance organization. For work of

limited scope it may be combined with the preliminary authorization.)

5.9.2 PLANNING AND ESTIMATING (P&E)

Planning and estimating is the process of developing the work order documenting the detailed work tasks and preparing an estimate of the resources required. The work order includes statements of the job steps or phases for each craft, a list of the required materials, the identification of special tools or equipment needed, an estimate of the time required for each phase, copies of sketches or drawings, the identification of safety requirements and required outages, and allowances for staging, travel, site cleanup, and other job-related actions. For contracted work, the work order is replaced by the statement of work (SOW) that includes sketches, a job specification or performance work statement, and a cost estimate appropriate to the contract form used. Planning and estimating provides the basis for:

- Deciding to approve, disapprove, or defer work.
- Developing costs and budget estimates.
- Determining the method of accomplishment.
- Preparing the shop load plan, the master schedule, and the shop schedule.
- Evaluating shop or contractor performance and efficiency.
- Establishing contract costs.

5.9.2.1 Facilities Maintenance Standards. Facilities maintenance standards are discussed in Chapter 7. They establish the level and condition to which facilities and

equipment are maintained. Standards serve as guides in determining the facilities maintenance work. P&E's determine the job tasks existing conditions with the prescribed maintenance standards and then selecting job tasks (maintenance actions) that bring the facility up to the standards.

5.9.2.2 Performance Standards. Planning and estimating is a skill requiring substantial knowledge of the crafts and methods involved; however, it is unlikely that one person is expert in all aspects of a craft. There are a number of estimating guides and standards available to assist P&E's in preparing work orders and estimates (see list in Appendix F). Equipment manufacturers also produce standards. All standards must be applied with care, taking into consideration local conditions, area cost factors, and experience. However, use of cost estimating guides and standards is encouraged as a means of improving the quality, reliability, and consistency of estimates. Performance standards include:

- a. **Engineered Performance Standards (EPS).** EPS are a comprehensive tool for planning and estimating facilities maintenance and related facilities work. EPS provide methodology and a series of standard maintenance tasks and task times that are combined to develop a work order and work order estimate. The system builds the estimate by aggregating the incremental times for tasks and adding time allowances for setup, cleanup, travel time, and local factors. EPS can be applied manually or by computer.

The estimates EPS produces are consistent and repeatable, and thus

provide good benchmarks for planning work and evaluating performance. EPS estimates are based on average craftsmen working with proper tools under average conditions. A well qualified crew will beat the EPS estimate consistently, and an inexperienced crew is likely to lag the EPS estimate.

Naval Facilities Engineering Command publications in the P-700 series provide detailed EPS guides, and training manuals. (See appendix F for a list of those publications.) A computerized version of EPS, contained in the Facilities Engineering Job Estimating (FEJE) module of the Public Works Management Automation CMMS, is available from the U.S. Department of Commerce, National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

- b. **Local Standards.** Local experience documented in maintenance history files is a valuable source of information for work order planning and estimating and may be used as a basis for standards. However, actual maintenance tasks and performance times for past work should be spot-checked against standards, such as EPS, to ensure that the times are reasonable and work practices are efficient, effective, and in line with current codes, standards, and technology.
- c. **Other Standards.** A variety of facilities cost estimating standards is available. Many are focused on new construction, renovation, or facilities

repair tasks; however, they can be useful in estimating maintenance work, especially work that is similar to construction, provided adjustments are made for job scope. One example of this is SPECINTACT, as managed by NASA headquarters, Code JXF.

Cost estimating systems are also available in computerized form, which speeds and assists estimate development. Appendix F lists several estimating standards.

5.9.2.3 Work Planning. Work planning is identifying specific tasks to be performed, phasing of those tasks, identifying the skills and crafts required for the tasks, and specifying the material and equipment for the tasks. It includes identifying specific health and safety requirements, coordination, outages, equipment availabilities, and other constraining parameters. EPS also provide assistance in work planning.

5.9.2.4 Cost Estimating. Cost estimates are developed by multiplying unit labor, equipment, and material costs by job task quantities and adding the appropriate burden rates for overhead and indirect costs. The exact form of the cost estimate depends on its intended use. For example, overhead costs, profit, bond expense, and taxes required for contract work are omitted for in-house Government work. Cost estimates can be classified in several categories.

- Scoping Estimate.
- Final Estimate.
- EPS-type Estimate.
- Historical Estimate.

Chapter 13 provides additional discussion on cost estimating.

5.9.3 FUNDING

Each work order includes a funding citation and accounting data identifying which funds to charge for the work. In some cases funds are customer-furnished (reimbursable). In others, funds are specifically budgeted by the Field Installation for facilities maintenance. When work is customer funded, appropriate funding documents should be furnished in a timely manner to ensure that work is not delayed unnecessarily. A correct fund citation ensures that the proper account is charged and provides valid accounting data for management reporting.

5.9.4 PRIORITY SYSTEMS

The work order system must make provision for differing work priorities. This allows high priority work to be done first while managing all work to ensure accomplishment in accordance with Field Installation needs. Figure 5-2 is a sample priority system. The priority is normally determined as part of the work review process. It guides material procurement, scheduling, and work execution.

5.10 FACILITIES MAINTENANCE WORK EXECUTION

After planning and approval, work management includes:

- Obtaining material, tools, and equipment.
- Scheduling the work.
- Performing the work.
- Monitoring work accomplishment.
- Reporting work completion.

GENERAL PRIORITY SYSTEM (5 LEVEL)		
<u>Priority</u>	<u>Description</u>	<u>Narrative</u>
1	Emergency	Safety; immediate mission impact; loss of utilities; begin immediately; divert resources as necessary; overtime authorized.
2	Urgent	Work that must be completed within a set time.
3	Routine	Facilities maintenance work that can be scheduled routinely within the capability of the facilities maintenance organization.
4	Discretionary	Work that is desired but not essential to protect, preserve, or restore facilities and equipment. Typically, new work that is not tied to a specific mission milestone.
5	Deferred	Work that may be safely, operationally, and economically postponed; may be included in the backlog of deferred facilities maintenance.

Figure 5-2. Sample Priority System

5.10.1 MATERIAL MANAGEMENT

Material management includes ordering, stocking, storing, staging, issuing, and receiving material for use on work orders. Material management may be performed by an element of the facilities maintenance organization, a central supply department not a part of the facilities maintenance organization, or a combination of these. (Tool management may be assigned to the same organization that has the material manager responsibility.) Working from material requirements lists prepared by

P&E's as part of the work order, the material manager is responsible for obtaining the material and advising the work schedulers when the material is available for job accomplishment. In the case of PM, other recurring and standing work, and Trouble Calls, material management should have available or provide ready access to frequently used parts and supplies. These may take the form of pre-expended shelf stock or vendors accessible under quick procurement instruments such as blanket purchase agreements.

The range and depth of material stocked should be based on historical demand, insurance items (spares for critical systems), and projected requirements for future work. Inventory high and low limits should be established based on use rates, economic reorder quantities, and delivery times to minimize investment in inventory. Where advantageous, "just-in-time" parts delivery should be used. Many automated maintenance management systems include support for computerized material management functions. Bar coding is used extensively in material management to speed data entry and reduce data entry errors.

5.10.2 SCHEDULING

Scheduling work orders is necessary to ensure a balanced flow of work to the shops in accordance with priorities, external factors (such as weather), and operational considerations. It facilitates optimum use of resources and provides information to optimize the distribution of shop staffing by craft. The AWP identifies resource levels for each facilities maintenance program work element. It also identifies major work items to a fiscal year. However, most facilities maintenance work orders, including Service Requests, will not have individual visibility in the AWP. They are included as part of a level-of-effort resource allocation for the fiscal year. Within the fiscal year, work scheduling may be done at three levels; i.e., the shop load plan, the master schedule, and the shop schedule. The relationship of these plans is depicted in Figure 5-3.

5.10.2.1 Shop Load Plan. The shop load plan is usually maintained by the organizational element responsible for the work control function. It schedules work to the shops

on a periodic basis, typically quarterly, and looks several quarters into the future. It reflects the backlog of estimated work as defined in the AWP for the current and following year. The shop load plan is dynamic. Work may be added or shifted among the schedule periods as new work is identified or work priorities change, although the plan for the next schedule period should be fairly stable. A Field Installation may find it convenient to divide the next quarter's shop load plan into a short-term (30-day) plan and a mid-term (following 60 days) plan for closer scheduling.

The shop load plan considers available production resources (i.e., man-hours by craft, tools and special equipment, contract limitations, etc.); availability of items to be maintained such as times for shutdowns; external factors such as weather; work already scheduled or in progress; allowances for recurring work such as PM, PT&I, and Trouble Calls; and long lead time material requirements. With these factors in mind, the planner loads work orders into each quarter to balance the workload for each maintenance resource and to ensure optimum employment of that resource within the work order priority system.

The shop load plan also facilitates analyzing the work force composition compared to the workload. It identifies personnel or skill shortages or excesses and gives facilities maintenance managers time to respond. Close coordination with the master schedule regarding the status of work in progress is required. Appendix D contains a sample shop load plan.

5.10.2.2 Master Schedule. The master schedule is maintained in the shops organization, usually under the direction of the

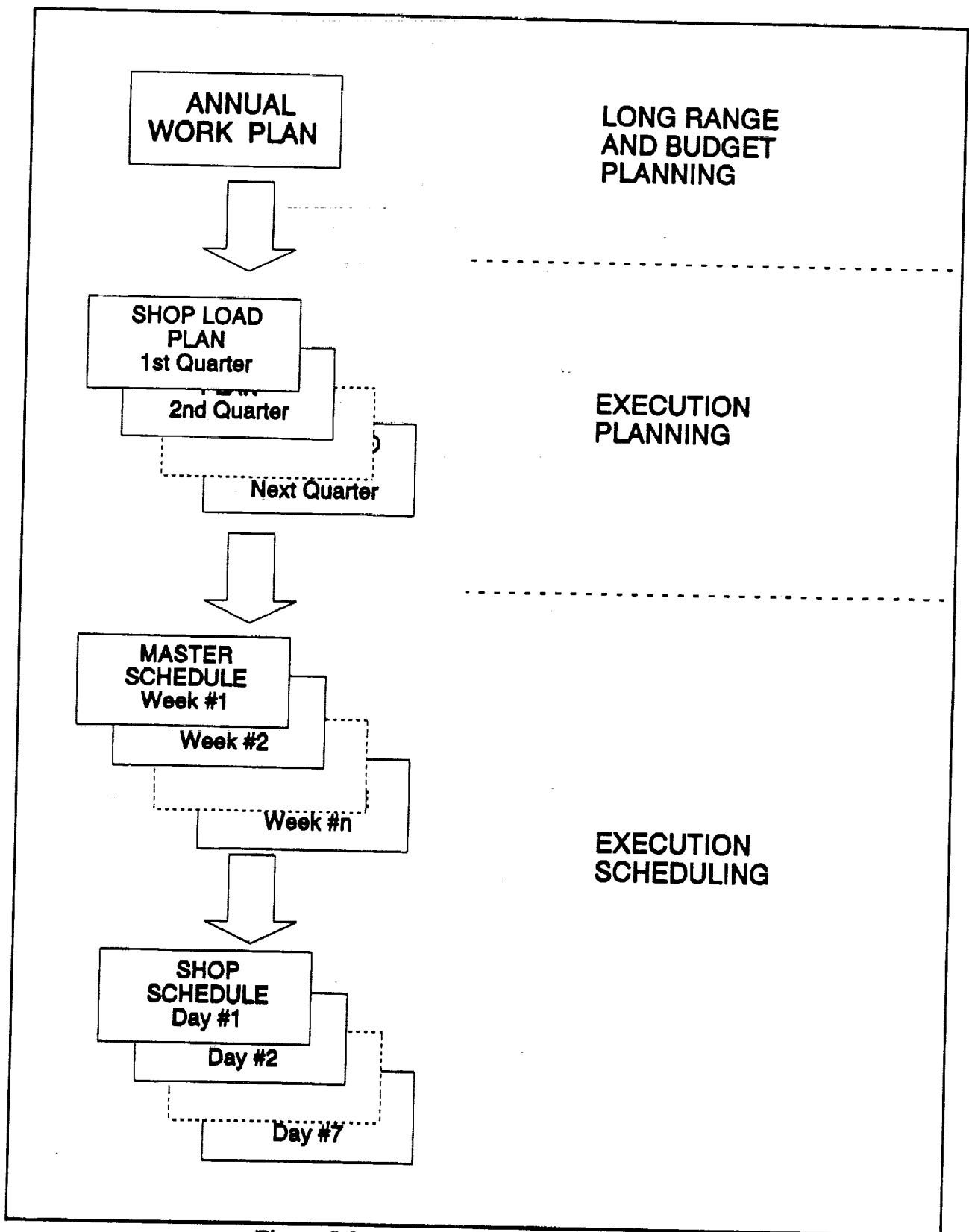


Figure 5-3. Work Scheduling Relationships

senior shop supervisor. Within the scheduling framework of the shop load plan, it is the week-by-week shop schedule, identifying jobs to individual shops. It covers a shorter time period than the shop load plan, typically 6 to 12 weeks. Work orders are initially placed in the master schedule and noted as awaiting material. When material is available and the job is ready to start, it is firmly scheduled. Close coordination with the shop load plan and shop schedules is required. The master schedule is dynamic, and it changes as priorities are adjusted, new work is identified, and material status changes. The shop load plan can be used as a model for the master schedule. Appendix D contains a sample master schedule.

5.10.2.3 Shop Schedule. Within the framework of the master schedule, the shop schedule is used to schedule the day-by-day work orders and craftsmen within a shop. It is maintained by the shop supervisor and used to assign work and track progress. The shop schedule can be patterned after the master schedule. Appendix D includes a sample shop schedule.

5.10.2.4 Schedule Automation. The shop load plan, master schedule, and shop schedule are all based on the same database, differing slightly in the information displayed and the period covered. It is possible to maintain a single scheduling system on a networked CMMS working from a shared database, provided the CMMS has the necessary scheduling features. This gives the added advantage of automatically coordinating the schedules and changes at all levels of management. Some CMMS may have an integrated scheduling module that provides functional equivalents to the shop load plan, the master schedule, and the shop schedules that can be used to prepare de-

tailed project schedules for the more complex work projects.

5.10.2.5 Scheduling Considerations. The following factors should be considered in scheduling work performance.

- a. Preventive Maintenance. PM (including PT&I) provides the baseline workload for the facilities maintenance shops. An effective PM program minimizes the need for Trouble Calls and Repair. Efficiencies can be obtained by using employees dedicated to PM work because they become familiar with the equipment. PM work orders should be scheduled and grouped by facility or geographic area to minimize travel.
- b. One-Time Work Orders. Work orders for one-time jobs require the greatest scheduling coordination and management effort. This is due to the unique requirements of each job.
- c. Repetitive Work Orders. These are similar to PM jobs in that they are a predictable level of effort and frequently are a continuing or repeating work requirement such as Grounds Care, street sweeping, relamping, and Central Utility Plant Operations Maintenance. Like PM, they are scheduled as part of the baseline shop workload.
- d. Trouble Calls. Trouble Calls are assigned to the first available qualified shop. Trouble Call work proceeds until the situation is corrected or stabilized. The final correction of a problem such as a water main break may require subsequent issue

of a Repair work order. Most Trouble Calls should be accomplished by the work center assigned to perform small jobs as discussed in paragraph 3.2.2.7. Equipping key facilities maintenance workers with radios or pagers can enhance response and productivity.

- e. Small Jobs. Small jobs, typically those requiring less than 20 man-hours and issued on a Trouble Call ticket (see Appendix D, Figure D-1), are normally worked on a first-come-first-served basis, subject to the availability of material. Because they can represent a fairly constant level of effort and normally involve routine methods and materials, it is common practice to have a shop dedicated to this size work.

This shop should be able to complete about 90 percent of the Trouble Calls and small work orders; the remaining 10 percent are used as fill-in work for other shops. This shop should be sized to be able to complete non-emergency work within 5 to 10 work days of receipt, subject to material availability. In the interest of efficiency and minimizing travel time, Small jobs may be grouped by building or geographic area. The use of dedicated, radio-equipped vehicles stocked with pre-expended, commonly used facilities maintenance material will improve the productivity.

5.10.3 WORK PERFORMANCE

When all material is available and coordination and scheduling are completed, the work order is executed. Work proceeds to completion in accordance with the approved work order. However, the shops should be free to communicate with the P&E's to resolve questions about the work. If field conditions differ substantially from the work order, or the effort and material required differ substantially from the work order estimate, the supervisor should check with the P&E for amendment or clarification and review the priority and schedule to ensure that completion dates will not be missed. The threshold for work order amendment is based on Field Installation management needs; however, a 20 percent or greater increase from the estimate is suggested as a deviation requiring a work order amendment.

5.10.3.1 Quality Control/Assurance. Shop supervisors have the primary responsibility for work quality control. When the work is completed, they should check with the customer to be sure that the work meets his needs. If customer expectation goes beyond the work order scope, the job should be referred promptly to the facilities maintenance manager for resolution.

5.10.3.2 Defective Work. Defective or rejected work occurs for a number of reasons, including poor workmanship, an incorrectly scoped and prepared work order, defective material, or poorly defined customer requirements. When defective work is discovered, it should be corrected to satisfy the operational needs and to meet safety requirements. Correction of safety related deficiencies should be accomplished immediately.

5.10.3.3 Rework Causes and Correction.

A decision to rework a job should be based on cost-benefit considerations, including Field Installation operational commitments, cost to rework the job, expected added benefit as a result of rework, and the availability of resources. Separate work orders should be established to accumulate rework data. The evaluation process should address causes of defective work and methods of reducing rework. Remedial actions may include revising internal procedures, providing additional employee training and skill development, changing material specifications, adding early material acceptance inspections, revising facilities maintenance standards and requirements, and increasing customer involvement with work order preparation and approval. Each Field Installation should have a policy for handling rework. In cases where rework of contract efforts is being considered, you should consult the cognizant procurement office.

In general, the customer should not have to bear the cost of facilities maintenance rework resulting from errors by another party, and the Government should not have to bear the cost of rework that results from a contractor's error. A rework clause should be included in contracts to require the contractor to perform rework at his own expense, to reimburse the Government for rework performed by the Government, or to reduce contractor payments for rework not performed. The amount of rework should be considered as an evaluation factor when determining contract award fees.

5.10.4 **COMPLETION REPORTING**

When work is completed, the work order is closed. The labor and material used are recorded for record and accounting purposes.

The results are recorded in the facility or equipment history files, and evaluation action is initiated. The information reported should include unanticipated conditions encountered, a concise description of the work accomplished, and additional material used but not listed in the work order. Work order forms (including Trouble Call tickets) should include space for the craftsmen to enter completion data. Completion data should be reviewed by the shop supervisors.

5.11 **MANAGEMENT INFORMATION SYSTEMS (MIS)**

5.11.1 **DEFINITION**

An MIS is an organized method of providing past, present, and projected information related to the internal operations of an organization. It supports planning, control, and evaluation functions by providing information to decision makers in a consistent, structured, and timely fashion. An MIS is not a decision-making system. Decision-making responsibility rests with the manager using the MIS. However, the quality of a manager's decision is dependent on the quality of the information he receives. Thus, the quality of MIS data directly affects the quality of management decisions.

To be fully useful, MIS information must be:

- Accurate
- Timely
- Relevant
- User-oriented
- Cost-effective

5.11.2 AUTOMATED MIS

While an MIS can be either manual or automated, computers provide powerful tools for supporting an MIS because of their ability to manage and manipulate large quantities of data. With modern data management software programs and through interconnection with other computers through local area networks (LAN's), the MIS can present data in various formats and arrangements to assist in the analysis of virtually all aspects of the functions that directly and indirectly impact facilities maintenance. Data can be presented in both printed and graphic form in hard copy or on a computer screen. Chapter 6 covers the advantages of automated facilities management information systems. The choice of an automated or a manual MIS rests with the Field Installation. This usually is based on factors such as cost, the amount of information, the availability of the information, and the needs of management.

5.11.3 DETERMINING MIS REQUIREMENTS

Reports, charts, and other displays that do not directly contribute to facilities maintenance management, other Field Installation, or NASA Headquarters needs are a waste of scarce resources. Therefore, information should be collected, processed, or documented to support a clear need. A summary of recommended facilities maintenance indicators and reports prepared by an MIS is given in paragraph 5.11.5. Field Installations should specify the information to be displayed and distributed in the reports.

5.11.4 COVERED FUNCTIONS

A comprehensive MIS should serve the full range of facilities maintenance functions.

5.11.5 ANALYSIS, REPORTS, AND RECORDS

The principal function of an MIS is to provide reports for management analysis and decision-making. The following is a list of suggested topics for reports and analysis that may be important to a facilities maintenance manager. Additional discussion of these is contained in Chapter 13.

- Status of Funds
- Work Status
- Status of Major Projects
- Annual Work Plan Updates
- Work Generation Statistics
- Work Execution Statistics
- Inventory Statistics
- Contract Status
- Material Status
- Utilities Statistics

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CHAPTER 6. FACILITIES MAINTENANCE MANAGEMENT AUTOMATION

6.1 INTRODUCTION

Effective facilities maintenance management requires the use and control of large amounts of information. This includes tracking incoming requests for facilities maintenance work, scheduling preventive maintenance, preparing budget estimates, projecting facilities maintenance requirements, and determining resource allocations. The input, storage, retrieval, manipulation, and display of this information is best accomplished by computers.

The past two decades saw the application of computer technology to facilities maintenance management expand as systems became more powerful, less costly, and easier to use. Automation products and processes evolved from purely record keeping and processing accounting data to task automation and decision support. Sharing information interactively with other systems and direct system access by end users are realities. Appendix C, reference 4 contains an in-depth examination of information needs, integration, and flow in a facilities maintenance management environment, which may be of use to NASA Field Installations.

Many commercial software products are available for use in facilities maintenance management. These systems are available for the full spectrum of computer hardware, from main frame computers to networked and stand-alone microcomputer systems. The quality, competitiveness, and changing nature of commercial software make in-house software development inadvisable. Further, rapid advancement in computer hardware and software technology makes it

inappropriate to recommend specific hardware or software systems in this handbook. This chapter presents factors for consideration when selecting, implementing, and using a commercial, off-the-shelf computerized maintenance management system (CMMS). Chapter 12 amplifies the information on the concepts and recommendations presented in this chapter.

6.2 AUTOMATED SYSTEM INTERFACES

Facilities maintenance management automation brings the benefits of automation to facilities maintenance functions and processes. Chapter 3 discusses the functions, processes, management concepts, and system of controls recommended for facilities maintenance. It also identifies closely related supporting functions and processes. The CMMS should directly support or interface with existing related automated systems such as financial accounting and personnel administration systems. CMMS must support the following major functions as they apply to facilities maintenance. (Chapter 12 contains a more detailed discussion of each item.)

- Manage facilities and equipment.
- Provide utilities services.
- Formulate and administer contracts.
- Develop budgets and perform cost analysis.
- Provide management support.

6.3 COMPUTER SYSTEM ARCHITECTURE

The primary value of the computer in facilities maintenance management is its ability to rapidly and accurately store, retrieve, manipulate, and output (including display or print) information according to rules and parameters set by the programmer/user. With current systems, the keys to success are:

- Ensuring that the information is accurate.
- Structuring the information in a way to permit establishing relationships between it and other information.
- Making the information available to users.
- Processing the information to support facilities and facilities-related equipment maintenance management.

These are the primary considerations when designing and developing a system. The following paragraphs discuss elements found in effective facilities maintenance management automation systems. Based on the scope of their capability, there are three classes of CMMS:

- Those that identify facilities maintenance tasks using input from sensors installed on the equipment without regard to the resources required to perform the tasks.
- Those that depend upon manual input of task identification but help with scheduling and otherwise managing the resources.
- Those that combine both of the above capabilities.

6.3.1 DATABASES

The facilities maintenance management information stored in the computer is the database. It may take several forms, depending on the system used by the programmer, and may be in the form of several related data files. The following lists the general types of information typically found in the database. Chapter 12 contains amplifying information on each.

- Facility/Equipment Inventory
- Facility/Equipment History
- Drawings
- Work Input Control
- Job Estimating
- Work Scheduling and Tracking Requirements
- Preventive Maintenance
- Continuous Inspection
- Space Management/Planning
- Tools/Material Management
- Contract Administration
- Utilities Management
- Environmental Compliance
- Administration/Personnel/Financial Management

6.3.2 SOFTWARE PROGRAMS

CMMS software evaluation criteria should include:

- User interface.
- Of-the-shelf.
- Options/configuration.
- Operating mode.
- Upgrade features.

Discussion of these follows.

6.3.2.1 User Interface. Screens and data displays should be clear, concise presenta-

tions making it possible for a user to find or enter information easily. Program flow should make it possible for the user to move readily from one operation to another. The program should minimize the chance for unintentional data loss due to operator error or system failures such as power outages. The program should include built-in error checking where possible to ensure that the data entered is correct and within acceptable ranges. For example, it should check entries to ensure that building numbers, cost account numbers, and work classifications are valid.

6.3.2.2 Off-The-Shelf (OTS) Software. OTS software is usually less expensive than custom-developed software. However, because OTS software attempts to serve a broad range of users, it may not contain features required by a specific user. Therefore, software should contain enough flexibility to permit users to tailor it to their needs. As an alternative, many software developers can provide customized versions to meet a specific user's needs at an additional cost. This may still be at a lower cost than custom software development. Finally, group buy of software for multiple sites can result in a reduced cost per copy.

6.3.2.3 Options/Configuration. Software programs should provide for data export to and import from industry standard file formats as well as a reliable means to electronically transfer existing data to a different software system. Software programs often come with such flexibility built in or available as an added-cost option. This permits customizing the software program to meet unique local requirements. This may include the ability to add data fields, change the format of data entry forms, reports, and similar actions.

Programs often are modular, each module providing for the automation of certain tasks or processes and interfacing with other modules. This permits implementing only those portions of a CMMS desired at a Field Installation, with an option to expand at a later time.

6.3.2.4 Operating Mode. Early maintenance management systems operated in batch mode; i.e., data entry and report processing took place periodically, such as once a day, week, or month. Current technology permits on-line, interactive use of maintenance management systems, where the user has immediate access to up-to-the-minute data. Field Installations should avoid batch systems.

6.3.2.5 Upgrade Features. The selected software system should provide for smooth transition to future systems. It should provide periodic updates or upgrades to include new features and technology. Further, it should provide for automatically transferring data from the old to the updated version; i.e., a reliable means of transferring existing data electronically to the new system.

6.3.3 **HARDWARE**

Hardware refers to the computer equipment. It includes:

- Central processing unit.
- Display terminal.
- Output devices such as printers and plotters.
- Data storage devices such as disk drives and tape drives.
- Input devices such as keyboards, bar code readers, date-time stamps, and remote sensors.

- Portable data collection and input devices.
- Notebook-sized computers.

Hardware technological advances have been occurring very rapidly. Hardware specification development should consider changes underway in the following areas:

- Off-the-shelf availability.
- Location or site.
- Access to the system.
- Miniaturization.

6.3.3.1 Off-The-Shelf (OTS) Hardware.

The use of standard OTS hardware can provide benefits. Care should be taken to select OTS hardware that is designed using open hardware systems; i.e., those for which the specifications are public so that any company can develop add-on products. This normally leads to the development of a wide range of competing software and equipment options that are lower cost than equivalent hardware using closed, proprietary systems. Ensure that the OTS microcomputer system selected can support networks and can be used for additional applications such as office automation.

6.3.3.2 Location. Modern computer hardware capable of providing maintenance management automation does not necessarily require a special, environmentally controlled computer space. Select hardware that can operate in a normal, office-type environment provided with the proper physical security. However, the space should have suitable lighting and low noise and dust levels.

6.3.3.3 Access. Access to a single-user (stand-alone) system is normally through the computer's keyboard. (Single-user systems are not adequate for large installations.)

Access to a multi-user system, typically through networked microcomputers, is the keyboard and monitor at each user's desk or work station. The use of multiple terminals makes it easy for multiple users to obtain information from the system and encourages system use.

6.3.3.4 Miniaturization. Miniaturization is leading to very compact, notebook-size computers that are easy to carry into the field. Users can connect to the CMMS computer network as required; for example, by dial-in phone lines from field sites. This gives field workers immediate access to information and permits rapidly updating data files with field findings and test results.

6.3.4 INTEROPERATION

Historically, most CMMS have been stand-alone systems, dedicated to providing single-task automation, even when sharing computer hardware with other data automation systems. This concept has changed with technological evolution. Now, interoperation is a significant advantage, adding considerable decision-making support capability. Features supporting interoperation include:

- Data exchange.
- Shared data.
- Distributed users.
- Common reports and forms.

The following paragraphs describe these capabilities.

6.3.4.1 Data Exchange. A computer system should be able to export and import data from other systems. This permits exchanging information between users of system not physically connected without the need to re-key the data. For example, this capability

permits the easy transfer of data into the system from portable computers used in the field.

6.3.4.2 Shared Data. The ability to share data with other organizations is a significant advantage. This permits maintaining only one master file of the information kept current by the owner of the data. Others with a need to use the information can share access. This may involve interconnections among systems. It is a rapidly developing capability. (See paragraph 6.4.7 regarding data security.)

6.3.4.3 Distributed Users. A system that supports distributed users permits each user to have access to a portion of the facilities maintenance database. This may be an advantage at Field Installations that have multiple organizations with responsibility for portions of facilities maintenance. It permits using a unified facilities maintenance database while providing facilities maintenance management support to each facilities maintenance organization.

6.3.4.4 Common Reports and Forms. Certain common reports and forms have NASA-wide application. An example is the annual budget submission. Additional areas may arise in the future. CMMS capability should provide information in standard formats and permit adding new formats as well as additional media types (disk, paper, electronic file transfer).

6.3.5 INPUT/OUTPUT

Input/output refers to the process of getting information into and out of the computer. These terms apply to the hardware, software, or human actions required. Systems selected should provide maximum flexibility

in input/output means and support the full spectrum of available technology. Systems also should support input/output from remote locations. Chapter 12 discusses input/output in more detail.

6.4 IMPLEMENTATION

Field Installation data processing personnel can provide valuable advice and assistance in selecting and implementing a CMMS. However, nothing can replace the technical expertise of the facilities maintenance managers in determining what the system should do. Facilities maintenance managers and staff should play the central role in the selection and implementation process if the CMMS is to meet their needs.

6.4.1 AUTOMATION MANAGEMENT

The initial question is: "How much is enough?" The scope of the CMMS depends on the Field Installation's need for automation and the scope of the facilities maintenance management task. It is wasteful to buy a system with features left unused or a system that cannot expand to meet foreseeable needs. Further, it is wasteful to gather and maintain data for which there is no need.

The selected system size and capability should meet predictable facilities maintenance management needs. Modular software can respond to this concern; however, hardware sizing probably should err on the high side. Applications and use typically expand faster than anticipated as users appreciate the benefits of the CMMS and demand more service. The cost of hardware is usually small in comparison with the life-

cycle cost of the software and the personnel cost for training and implementation.

6.4.2 BUYING/SELECTING

Specifications for hardware systems and software should call for proven systems that meet user needs. This way, the benefits of automation are immediate rather than dependant on some future development. If selection criteria includes the upgrade concept (see paragraph 6.3.2.5), data can move to a future, more capable system when necessary. A modular CMMS offers advantages. The option to lease rather than own the hardware should be subject to an economic analysis; however, ownership is usually the lower cost option. OTS software purchase is usually subject to a license agreement that may include recurring annual costs for updates and user support. (Selection of the same CMMS by several Field Installations may offer savings through economies of scale in licensing and training and through the ability to share data easily.) Appendix E contains a CMMS selection guide.

6.4.3 OWNERSHIP OF DATA

The responsibility for CMMS data accuracy and maintenance (sometimes called ownership) should rest with the organizational element most dependent on that information. This ensures an interest in keeping the information up to date. To the maximum extent possible, the responsibility for the development and maintenance of a database should rest with the person most knowledgeable about the information contained in that database.

6.4.4 SYSTEM ADMINISTRATION

Data automation systems require periodic maintenance to ensure smooth operation. Maintenance ranges from regularly backing up data files (to lessen the chance of data loss), to installing new program releases, and updating information on authorized system users. This may be a primary or collateral responsibility, depending on the size of the CMMS. The source of this support and the effort required also depend on the size of the CMMS, its location, the applications running on the system, and other site-specific factors. For systems operating on a network within the facilities maintenance organization, this would typically be by an employee of that organization. The facilities maintenance organization must plan and budget for administration and support as a continuing expense for any automated system.

6.4.5 TRAINING

New or upgraded systems require training for new users and refresher training for existing users. The training should coincide with system start-up. In this way users receive training as their modules come on line. This timing reduces discouragement caused by trying to use a new system without adequate training, or losing skills learned in training due to a lapse before using them in the work environment. All users including managers, should receive training.

Training should fit each user's needs. Training appropriate for a work reception clerk will not meet the needs of a senior line manager. Field Installations should plan and budget for training with the initial acquisition and with post-implementation adminis-

tration. Often, training is available from the hardware and software suppliers. Although OTS software frequently has a tutorial feature and lesson plans, these may not provide sufficient instruction for many users.

6.4.6 TRANSITION TO NEW SYSTEM

Setting up a new CMMS includes installing hardware, installing selected software, loading data, converting existing records, testing the new system, and transitioning from the old to the new system. The time and effort required depend on the scope of the new system and how big a change the new system is from the old system. The transition may include parallel operation of both the old and the new systems during the change over and may result in reduced efficiency during the learning phase.

Where electronic data transfer between the old and new systems is not possible, data loading may require considerable effort. Transitioning to the new system also may require gathering additional information on facilities, equipment, and maintenance requirements and then manually entering the information. This should be a high-priority, dedicated task to ensure that the new system is complete and ready for use as soon as possible after initial installation. Planning and budgeting for a new CMMS should provide for data entry.

6.4.7 INFORMATION SECURITY

A system should provide for security to protect data, programs, and hardware. Security includes protection from the environment, accidental damage or loss, theft or vandalism, and unauthorized access, use, or alteration. OTS software is usually subject to

copyright restrictions on copying, distribution, and use. Security measures include password control for program and data access, equipment physical security, data backup, lightning and surge protection, and uninterruptable power supplies. However, a balance between security and system use is necessary. Users must have ready access to their data. The Field Installation ADP or Security Office can provide expert help in these matters, especially as regards sensitive or Privacy Act information. NASA policy on information security is contained in NMI 2410.7.

6.5 DECISION SUPPORT

The CMMS should provide decision support features, including the ability to perform trend analyses and conduct "What if?" studies. Chapter 12 discusses management decision support in more detail.

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CHAPTER 7. FACILITIES MAINTENANCE STANDARDS AND ACTIONS

7.1 INTRODUCTION

Chapter 1 requires Field Installations to use maintenance standards, to conduct periodic condition assessments of their facilities against the maintenance standards, and to determine and carry out the maintenance actions required to meet the standards. This chapter provides suggested methods to develop and implement maintenance standards, condition assessments, and maintenance actions.

7.2 MAINTENANCE STANDARDS

A maintenance standard is the expected condition or degree of usefulness of a facility or equipment item. It is often a statement of the desired condition and a minimum acceptable condition beyond which the facility or equipment is unsatisfactory.

7.2.1 TYPES

Standards may take many forms. Some examples are:

- Elapsed time since last overhaul.
- Error or leakage rate.
- Wear (e.g., remaining tread).
- Chemical composition.
- Vibration level.
- Availability.

The standard applicable to an item depends on the item, its intended use, and the mission criticality or health and safety aspects of that use. Thus, identical items can have different standards when used for different applications. Maintenance standards provide benchmarks for facilities condition assess-

ments, predictive testing & inspection, preventive maintenance, operator inspection, and determination of maintenance requirements.

7.2.2 SOURCES

There are many sources of maintenance standards, each with different force, effect, and applicability. Appendix F contains a list of publications that provide information on maintenance standards. Some cover specific types of facilities and equipment; others are more general. Common sources are:

- Laws and regulations.
- Manufacturers or vendors.
- Trade or industry associations.
- Government publications.
- Locally developed standards.
- Specialized standards.

7.2.3 SETTING STANDARDS

7.2.3.1 Existing Facilities. Normal practice is to set standards while establishing a maintenance program for a facility or equipment item. The source of the standard used is that which best covers the operational use of the facility or equipment. Where individualized standards are necessary, knowledgeable operations and maintenance personnel should work together to develop and document an appropriate standard. Paragraph 8.4 discusses a process for developing standards for existing facilities.

7.2.3.2 New Facilities and Equipment. Historically, the vendor or contractor has been the source of maintenance standards and related information (including mainte-

nance procedures) for new facilities and successful. An alternative is to develop facilities maintenance support information for the new facility or equipment as part of the design process. Paragraph 8.4 provides further discussion of this methodology.

7.2.3.3 Methods of Setting Standards. The unique nature of many NASA facilities makes it likely that facilities systems exist for which there are no existing maintenance standards or requirements. In these cases Field Installations must develop a maintenance plan and supporting Preventive Maintenance (PM) and Programmed Maintenance (PGM) actions. There is another method of setting standards that can be used by Field Installations, either in-house or by A&E contract as described in paragraph 8.4. The method is called Reliability-Centered Maintenance (RCM). Figure 7-1 provides a decision tree for use in an RCM analysis (Appendix C, reference 27). Using RCM develops maintenance standards for ensuring that a system meets its designed reliability or availability. It determines maintenance requirements by considering the following questions:

- What does the system do?
- What failures are likely to occur?
- What are the likely consequences?
- What can be done to prevent them?

Answering the questions "What does the system do?" and "What failures are likely to occur?" provides the basis for the maintenance standard. The answer to "What can be done to prevent them?" is the basis for maintenance actions.

Underlying RCM is the concept that maintenance actions should result in a real benefit in terms of improved safety, required opera-

tional capability, or reduced life cycle cost. It recognizes that unnecessary maintenance is counterproductive and costly and can lead to an increased chance of failure or accelerated wear. The following presents a brief outline of the RCM steps. Reference 26 contains more information on RCM.

- a. **Identify system functions.** This is the capability or purpose of the system. It can be an on-line function such as a circulating pump, where its operational state is immediately known (the circulating pump is pumping). Or it can be an off-line function whose operation is intermittent such as a sump pump, and its condition is only known by an operational test or check. Functions may be active, such as pumping a fluid, or passive, such as fluid containment. Functions may also be hidden, in which case there is no immediate indication of a failure. This typically applies to emergency or protective systems such as a circuit breaker that operates only in case of a short circuit (electrical failure of another system or component).
- b. **Identify failures.** A failure is a condition that prevents the system from performing its function. The analysis identifies potential system failures and ways to detect them. It also identifies pre-failure conditions that indicate a failure is imminent. (The latter is a basis for Predictive Testing and Inspection (PT&I).)
- c. **Identify the consequences of failure.** The most important consequence of failure is a threat to safety. Next is a threat to the environment or mis-

sion accomplishment (operating capability). The analysis should pay close attention to the consequences of the failure of infrequently used, off-line equipment and hidden function failures. Also, consider the benefit (reduced consequences of a failure) of redundant systems.

- d. Identify the failure process. Determining the methods of and reasons for failures provides insight into ways to detect or avoid failures. The examination should consider factors such as wear, overload, fatigue, or other processes.
- e. Determine what can be done. Options include:
 - Modify the System. Redesigning the system to eliminate the weakness may be the most desirable solution since it can eliminate a potential cost. However, redesign may not be possible in many facilities maintenance situations.
 - Define the PM Task. A PM (or PGM) task may be identifiable that will lessen the chances or consequences of a failure. Maintenance tasks can be time directed (e.g., every 8 weeks), condition directed (e.g., when pH is greater than 7.3), or inspection directed (e.g., if a component is found worn).
 - No PM Required. It may be that the economic or operational cost of the failure is insignificant or substantially less than the cost of any effective redesign or maintenance

procedure. In this case it does not make business sense to implement a PM or PGM task.

- Accept the Risk. This concept is primarily directed toward safety or environmentally related failures where there is no identifiable action to further minimize the chance of failure. In this case identify and quantify the risk and make sure that all concerned are aware of it and of appropriate recovery procedures.

7.2.4 USES

Standards are the basis for condition assessments, for determining maintenance requirements, and for guiding operators in performing operator checks. Appendix G includes a sample maintenance standard and inspection checklist.

7.3 FACILITIES CONDITION ASSESSMENT

NMI 8831.1 and paragraph 1.14 require periodic condition assessments of Field Installation facilities. This section provides a suggested approach to condition assessments.

7.3.1 INSPECTION

Inspections are the cornerstone of facilities maintenance management. They identify needed maintenance work, provide feedback on the effectiveness of the facilities maintenance program, and form the basis for changes to the program. It should be noted that if unsafe conditions are uncovered during an inspection, that the installation safety office should be notified immediately.

7.3.1.1 Inspection Types. Inspections can be classified as:

- a. Continuous Inspections. Continuous inspections are scheduled examinations and tests of facilities and equipment to determine physical condition. They are inspections only, rather than operational or maintenance actions. They may require specialized skills, tools, or equipment. Continuous inspections are the primary means of making a facilities condition assessment. They also provide a check on the effectiveness of PM programs and operations. Some publications use the term Specialized Inspections to refer to continuous inspections such as elevator inspections that require specialized expertise not found within the maintenance force.
- b. Preventive Maintenance Inspections (PMI). These are the examinations, minor adjustments, and minor repairs (no larger than trouble call scope) of equipment included in a PM program. PMI typically covers untended equipment.
- c. Operator Inspections. These are the examinations, lubrication, and minor repairs (no larger than trouble call scope) and adjustments of equipment and systems that have an operator assigned. Typically, they apply to equipment or systems such as those in a central utility plant.

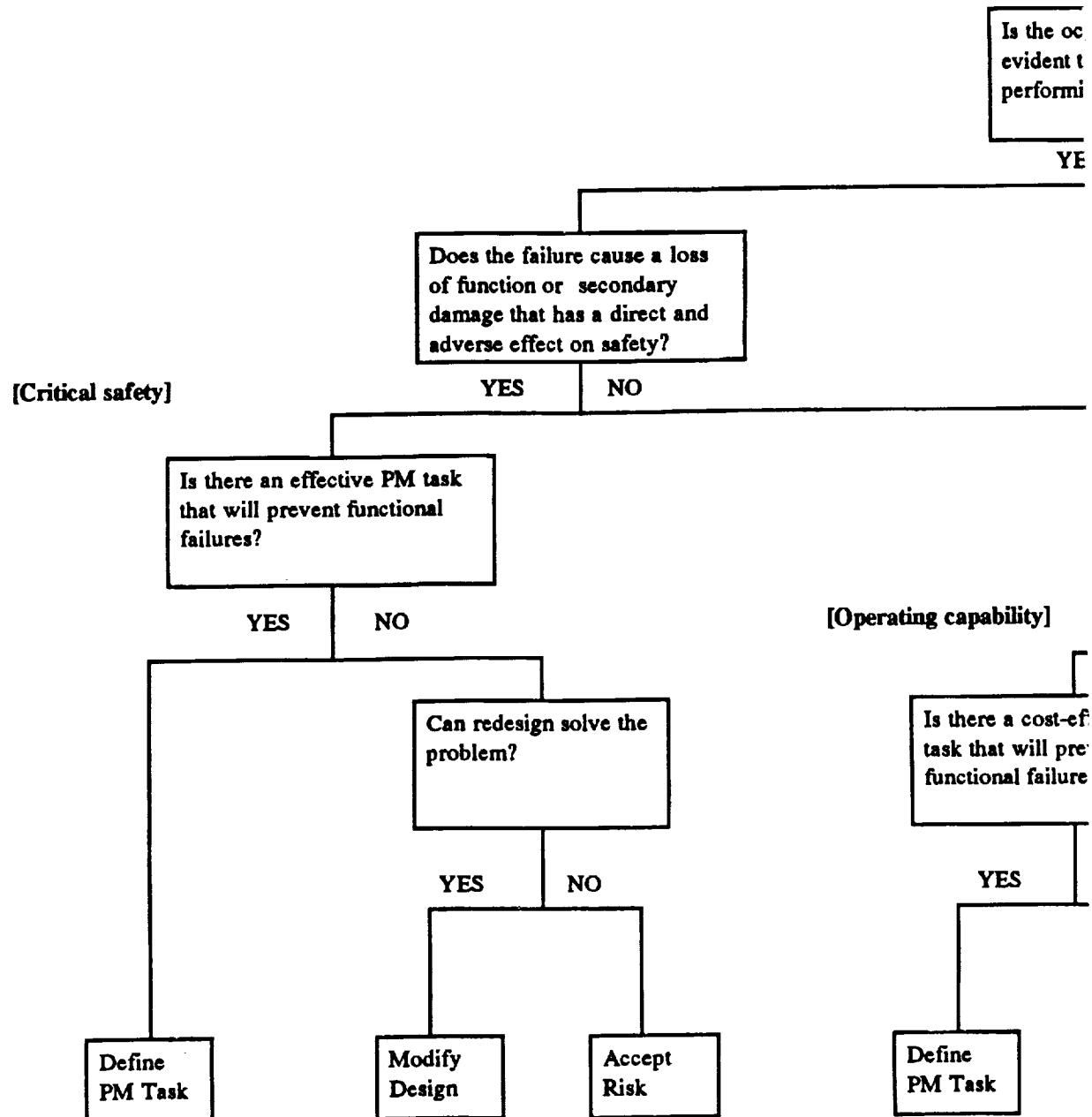
7.3.1.2 Inventory. The facilities and equipment inventory is the baseline for what is inspected and maintained. The inventory should permit identifying inspected items,

items subject to preventive maintenance inspection, and items subject to operator inspection. Paragraph 8.3 discusses facilities and equipment inventories.

7.3.1.3 Inspection Procedures. Preparing for and conducting an inspection involves the following steps. All steps may not apply in the case of recurring inspections such as PMI and operator inspections.

- a. Identifying the items to be inspected, based on the inventory.
- b. Obtaining the facility or equipment history. This includes information on completed Repairs, Modifications, and pending work orders, as well as the results of past inspections and the current use of the facility or equipment.
- c. Reviewing the applicable maintenance standards with a view toward the planned use of the facility or equipment. (Facilities or equipment scheduled for disposal or inactivation will normally have lower maintenance standards.)
- d. Identifying planned changes to the configuration and use of the facility or equipment.
- e. Identifying the inspector skills, specialized tools, and equipment required for the inspection.
- f. Scheduling the inspection, considering the operational requirement for the facility, the availability of inspectors, and related factors. Factors such as safety certification requirements, mission criticality, observed

RELIABILITY-CENTERED MA





MAINTENANCE DECISION LOGIC TREE

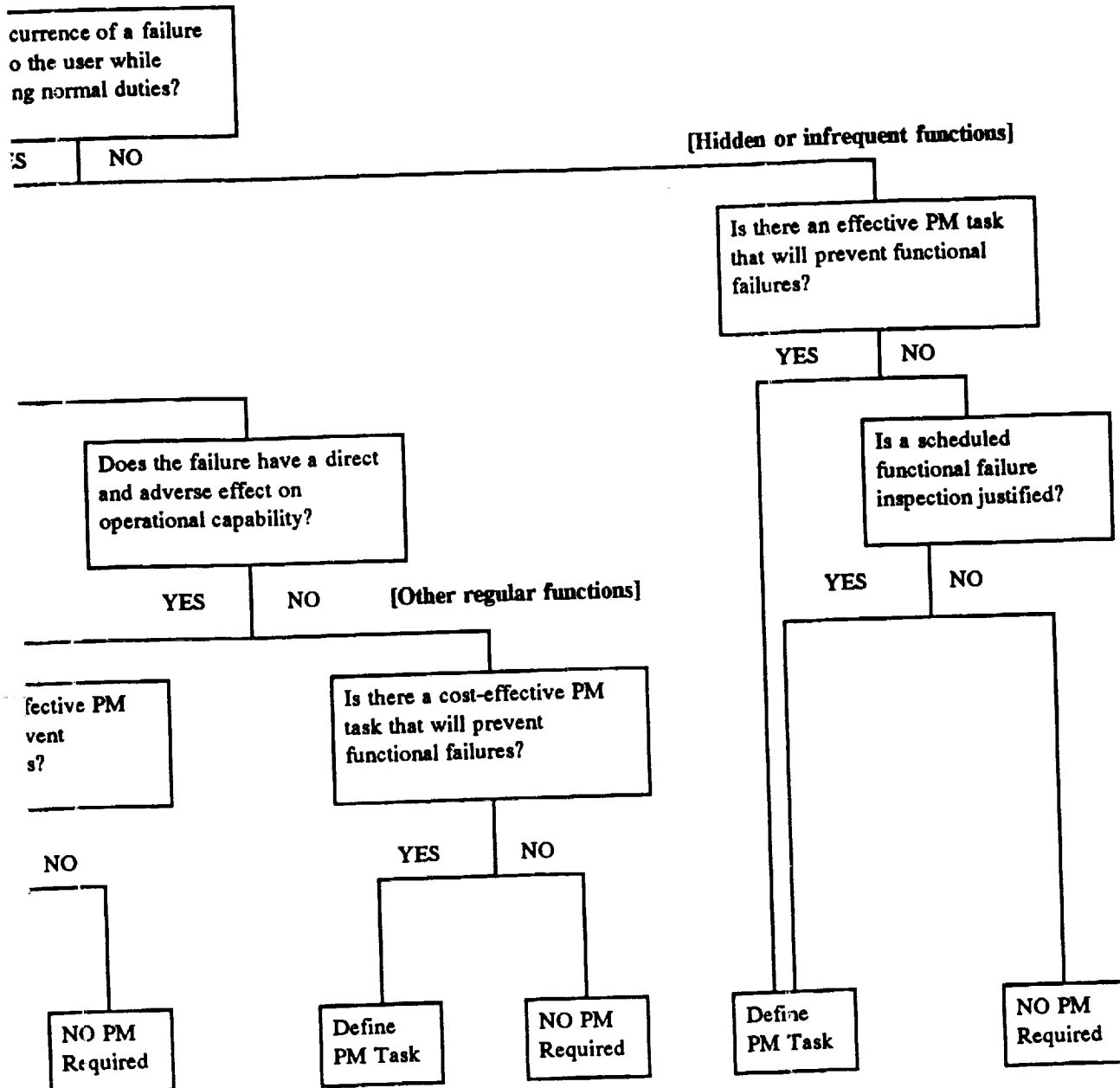


Figure 7-1. RCM Decision Logic Tree

rate of deterioration or condition change, and system availability determine inspection schedules and frequency.

- g. Conducting the field inspection, documenting the conditions found. The documentation should be a clear and concise presentation of the conditions found and permit determining and estimating corrective action. (Serious and safety-related deficiencies should be entered into the work control system for immediate action.)

7.3.1.4 Inspection Follow-up. The following actions are normally taken with regard to deficiencies found during an inspection:

- a. Reporting the conditions and recommendations to cognizant maintenance managers for decisions on corrective action. Corrective action could range from:
 - Issuing work orders.
 - Including corrective action in a future Annual Work Plan.
 - Preparing a facility project.
 - Modifying maintenance standards or actions.
 - Including the deficiency as part of the backlog of deferred facilities maintenance.
 - A combination of the above.
- b. Identifying and estimating recommended corrective actions. The cost estimate typically is a scoping estimate. However, repair work orders normally require a detailed final estimate.

7.3.2 PREDICTIVE TESTING

Predictive testing can reduce facilities maintenance costs and improve availability by enabling just-in-time maintenance of facilities systems and related equipment. Predictive testing monitors the condition or operating parameters of facilities system components to detect trends or conditions that indicate excessive wear or impending failure. This permits initiating timely maintenance actions. There are embedded or on-line systems for continuous readings and portable systems for periodic readings. Software is available to integrate or interface predictive testing results with CMMS.

Some examples of predictive testing methods and applications are:

- Oil analysis for wear metals and lubricant properties.
- Vibration analysis of bearings.
- Ultrasonic sound analysis for leaks.
- Infrared thermography scans for heat build-up or loss.
- Nuclear moisture analysis for roof and insulation failure.
- Magnetic signature or X-ray testing for ferrous metal failure.

Predictive testing technology is evolving rapidly. Each Field Installation should explore applications, especially for critical or costly systems not easily inspected by conventional means. Appendix H provides additional information on predictive testing methods and applications.

A method of deciding when to use predictive testing is to apply the RCM approach. Paragraph 7.2.3.3 provides information on RCM.

7.3.3 FREQUENCY OF INSPECTION

As the name implies, continuous inspection should be ongoing, with all facilities and equipment inspected periodically. Where a continuous inspection program has not been in effect, a one-time comprehensive condition assessment is necessary to provide an initial baseline and to develop procedures for a continuous inspection program. The frequency of inspection depends on a number of factors including:

- Importance of the facility.
- Legal or regulatory requirements.
- Likelihood of condition changes since the last inspection.
- Safety considerations.
- Availability of inspection resources.

Table 7-1 provides suggested inspection intervals for a number of facilities and systems. These are for facilities and equipment under average conditions supporting routine operations. Field Installations should adjust the frequencies to suit local conditions, regulatory requirements, and operational requirements.

7.4 MAINTENANCE ACTIONS

Maintenance actions are the specific work tasks performed by the maintenance workers.

7.4.1 USE OF MAINTENANCE ACTIONS

Maintenance actions are the basis for work orders, work force scheduling, and preparing budget estimates and work plans. Maintenance actions used in work orders are normally detailed, covering task specifics,

while actions used for budgeting and long-range planning are more often generic or statistically derived.

7.4.2 TYPES

Examples of maintenance actions are:

- A prescribed series of actions performed at a given interval (as in a preventive maintenance guide).
- Actions or adjustments to set or create a specific condition.
- A series of inspections or tests.
- Actions required to correct a maintenance deficiency.

7.4.3 SOURCES

Maintenance actions come from many sources. They often evolve from associated standards. The sources of standards discussed in paragraph 7.2.2 are also sources of actions.

Many of the publications identified in Appendix F give both maintenance actions and standards. Some CMMS programs include generic maintenance actions, typically covering PM on common equipment types. The manufacturer's PM and PGM recommendations should be a part of the maintenance documentation furnished with new equipment. Acquisitions of new equipment with unusual or specialized maintenance requirements should provide for the initial training of the maintenance force in meeting those requirements.

7.4.4 SETTING REQUIREMENTS

This section discusses setting requirements for normal maintenance program execution. Paragraph 8.4 presents a means for docu-

SUGGESTED INSPECTION INTERVALS
(Under Routine Operations and Average Conditions)

<u>ITEM INSPECTED</u>	<u>INTERVAL (years)</u>
Antenna-supporting Towers & Masts	2
Boilers and Water Heaters	1
Bridges	2
Building Structure	3
Building Electrical Systems	2
Bulk Fuel Storage	2
Cathodic Protection Systems	6 mos.
Chimneys and Stacks	2
Drainage and Erosion Control	1
Dredging, Moorings	3
Electrical Distribution Systems	1
Electrical Vaults, Manholes	2
Elevators, Lifts, and Dumbwaiters	1
Exhaust Systems	1
Explosive Storage Buildings	2
Explosive Building Grounding Systems	6 mos.
Fences, Walls	2
Fresh Water Storage	2
Fuel Facilities (Receiving and Issue)	1
Grounds	3
HVAC Systems	1
Inactive Buildings, Facilities	5
Pavements	1
Piers and Wharves, etc.	1
Plumbing	2
Power Switches, Instruments, Potheads	2
Railroads	1
Roofs	1
Sewage Collection and Treatment Systems	1
Steel Power Poles and Structures	3
Trusses	1
Water Treatment and Distribution Systems	1
Wood Poles	2

Table 7-1. Suggested Inspection Intervals

menting maintenance action requirements for new facilities and equipment as part of the design process.

7.4.4.1 Preventive Maintenance (PM). PM has a well defined set of maintenance actions for each equipment item included in the program. The actions are typically a series of tasks and checks in the PM work order. Performance standards, historical knowledge, analysis, experience, design, and manufacturer's recommendations are the basis for the PM actions. Each PM of an item does not require developing new PM actions. Normal practice is to use the same PM tasks until they no longer apply. Sub-standard conditions that are outside the scope of the PM work order should result in a Repair work order. They also should cause a re-examination of the PM tasks and schedule to determine whether changes are necessary. The RCM approach presented in paragraph 7.2.3.3 can help determine PM actions.

7.4.4.2 Programmed Maintenance (PGM). PGM actions, by virtue of their longer interval, usually include more work than PM actions. PGM schedules and tasks normally rely on prior inspection of the facility, component, or equipment under consideration. The PGM actions may incorporate well defined, routine maintenance actions as in a PM work order. The RCM approach presented in paragraph 7.2.3.3 can help determine PGM actions.

7.4.4.3 Repair. The specific condition of the facility or equipment, evaluated on a case-by-case basis, determines Repair actions. Except for small jobs, planning and estimating by an engineer or a P&E is the normal method of developing the actions. The manufacturer's repair or trouble-shoot-

ing guide frequently is used in defining Repair actions.

7.4.4.4 Replacement of Obsolete Items (ROI). ROI actions also rely on case-by-case determinations, although the determination can apply to a large number of like items. Examples include the replacement of motor controllers no longer parts-supportable or the replacement of water supply isolation valves to meet revised building codes.

7.4.5 FACILITIES MAINTENANCE CYCLES

Table 7-2 provides examples of selected facilities maintenance tasks, with the cycle or interval between performances of the task suggested for use by NASA Field Installations. The intervals listed assume average conditions. Field Installations may adjust these to suit local use and environmental conditions.

7.5 CENTRAL UTILITY PLANT OPERATIONS & MAINTENANCE

Central Utility Plant Operations & Maintenance involves a significant integration of facilities and equipment inspection and maintenance with operations. Plant operators perform the facilities maintenance and inspection tasks as part of their operating routines.

7.5.1 STANDARDS

Central utility plants are usually process oriented, providing a product or service, with emphasis on availability and reliability. Standards developed for Central Utility Plant Operations & Maintenance have this focus.

<u>TASK</u>	<u>CYCLE (YEARS)</u>
Painting	
(Interior)	
Office areas, corridors, rest rooms	5
Industrial areas, high bays, hangars, machine shops, clean rooms	15
(Exterior)	
Personnel doors & jambs, overhead doors	4
Steel siding, piping, exhausters, air dryers	8
Wind tunnel shells, vacuum spheres, high pressure gas bottles	10
Pavements	
(Asphalt)	
Sealcoat, slurry coat	6-8
Overlay (1-1/2")	
Roads	15
Parking lots	20
Restriping	
Roads	2-4
Parking lots	5-8
(Concrete)	
Joint sealant, replace 10%/year	10
Crack repairs, average linear feet/year	2
(Sidewalks)	
Replace broken curbs, 10% of total/year	10
Replace broken/deteriorated sidewalks, 10% of total SF/year	10
Roofing	
Floodcoat built up roofs, 10% of total/year	10
Refasten flashing, cut and patch bubbles, clean/repair gutters/downspouts, 20%/year	5

Table 7-2. Selected Facilities Maintenance Cycles

These standards should identify conditions that require non-operator assistance as well as conditions addressed by the operator. The methods for setting standards discussed in paragraph 7.2 are applicable.

7.5.2 MAINTENANCE ACTIONS

PM actions are frequently a part of the operating procedures for central utility plants and are performed by the operators as

part of their routine watchstanding duties. Additionally, plant operators may be directly involved with the Repairs, Replacement of Obsolete Items, and Programmed Maintenance on those portions of the plant they operate. Maintenance action development uses the techniques discussed in paragraph 7.4.

7.6 CENTER APPEARANCE AND GROUNDS CARE

7.6.1 STANDARDS

Facilities design, colors, facades, and landscaping should fit in with other external architectural features including signage, traffic flow, and visual and acoustic barriers. The resultant system should blend with local community standards and decor and properly represent NASA to the public. Where possible, the plan should emphasize low maintenance features. Specific design guidelines are beyond the scope of this handbook. Facilities master plans often include landscaping plans, standards, and guidelines prepared by landscape architects. Landscape plans should include recommended maintenance actions. Facilities maintenance planning, including inspections and recurring maintenance, should ensure that facilities and grounds appearance represent NASA's objective of having world class facilities.

7.6.2 GROUNDS CARE GUIDELINES

A large number of resources are available for obtaining guidelines for grounds care. These include Government publications, local agricultural extension services, trade and industry publications, and commercial grounds care services. Grounds maintenance

plans should conform to the Field Installation master plan and have the support and approval of senior Field Installation managers. Grounds Care frequently involves using controlled chemicals such as pesticides and herbicides, fertilizers, and other materials with potentially adverse environmental impacts. All work plans should include appropriate environmental and safety requirements.

7.6.2.1 Maintenance Levels. Based upon land use, frequency of visitation, and visibility, Field Installations may wish to vary the quality (and cost) of grounds maintenance services specified for different parts of the installation. The following four levels are suggested:

- Level I - Administrative areas
- Level II - Industrial, warehouse areas
- Level III - Open storage, waterfront areas
- Level IV - Railroad and power line rights-of-way

Each maintenance level contains a distinctive mix of service requirements.

The service quality decreases as the maintenance level increases. For example, grass cutting weekly in Level I, every two weeks in Level II, monthly in Level III and quarterly in Level IV (sufficient to reduce the fire hazard).

7.6.2.2 Level of Service. There are two methods of specifying the level of Grounds Care maintenance: frequencies and standards. Grounds Care contract experience over many years at different locations has shown that specifying frequencies is preferable to specifying standards. Frequencies are

easy to plan, schedule, enforce, and estimate costs. Grounds Care standards such as grass height or shrubby appearance are difficult to estimate and enforce.

7.6.2.3 Performance Requirements Summary. Grounds Care contracts should contain a performance requirements summary in simple tabular form. Table 7-3 is a sample of a performance requirements summary.

**SAMPLE GROUNDS CARE CONTRACT
PERFORMANCE REQUIREMENTS SUMMARY**

<u>PERFORMANCE INDICATOR</u>	<u>STANDARD OF PERFORMANCE</u>	<u>MADR*</u>	<u>METHOD OF SURVEILLANCE</u>	<u>% OF COST</u>
1.A CONTRACT REQUIREMENT: GRASS CUTTING, MAINTENANCE LEVEL I				
A. Grass cutting and trimming completed during specified periods and as scheduled.	Attachment J-C1, Contractor's approved schedule in statement of work.	5%	Planned Sampling	15%
B. Debris removed	Collected prior to cutting, removal from site, no clippings left on walks, streets, etc. (Paragraph ___ in statement of work)	5%	Planned Sampling	15%
C. Grass Cutting	Uniform height btwn ___ and ___ inches, clippings distributed (Paragraph ___ in statement of work)	5%	Planned Sampling	20%
D. Trimming	Matches height and appearance of surrounding mowed area (Paragraph ___ in statement of work)	5%	Planned Sampling	20%
1.B CONTRACT REQUIREMENT: EDGING, MAINTENANCE LEVEL I				
A. Edging completed during specified period(s) and as scheduled	Attachment J-C1, Contractor's approved schedule (Paragraph ___ in statement of work)	5%	Planned Sampling	15%
B. Quality edging	Clear zone provided 1/2" wide by 1" deep, vegetation removed from cracks, etc. (Paragraph ___ in statement of work)	5%	Planned Sampling	15%
C. Vegetation/debris removed	Debris from edging removed off site same date (Paragraph ___ in statement of work)	5%	Planned Sampling	15%
1.C CONTRACT REQUIREMENT: PLANT AND SHRUB PRUNING, MAINTENANCE LEVEL I				
A. Pruning completed during specified period(s) and as scheduled	Attachment J-C1, Contractor's approved schedule (Paragraph ___ in the statement of work)	10%	Planned Sampling	15%

* MADR - Maximum Allowable Defect Rate

Table 7-3. Sample Grounds Care Performance Requirements Summary

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CHAPTER 8. PHYSICAL PLANT INFORMATION

8.1 INTRODUCTION

Information describing the facilities and maintainable collateral equipment at a Field Installation is essential for planning facilities maintenance actions, efficiently performing facilities maintenance, documenting maintenance histories, following up maintenance performance, and management reporting. Without this information, neglect of essential systems is likely, leading to inefficient operation, system failure, or loss of service.

This chapter discusses obtaining physical plant information for an effective facilities maintenance program. It addresses methods for both new and existing facilities and collateral equipment. With the increasing use of computerized maintenance management systems (CMMS), obtaining the information in computer readable form is strongly recommended.

8.2 DATABASES

Complete physical plant information consists of several databases distinguished by the type of information they contain. Chapter 6 discusses databases from the perspective of facilities maintenance management automation. This chapter examines them in terms of the type of information they contain.

8.2.1 DESCRIPTIVE DATA

Descriptive data is the detailed identifying information on the items to be maintained. The data falls into two classes:

- Facilities data describing buildings, structures, utilities lines, and grounds improvements.
- Collateral equipment data describing built-in equipment that is part of a facility or utilities distribution system but maintained as a separately identifiable entity.

Each separately identified and maintained item may be part of a hierarchy of systems and sub-systems. For example, a motor may be a component of the water circulating sub-system of an air conditioning system in a facility.

Descriptive data should identify items to their related systems and sub-systems. The number of hierarchical levels depends on Field Installation requirements, but four levels of system/sub-system is the suggested minimum. For equipment, the descriptive data should include the equipment classification or grouping.

8.2.1.1 Facilities. Table 8-1 provides a listing of descriptive factors and attributes used to develop a facilities database. This list is a suggested minimum for facilities maintenance management.

8.2.1.2 Collateral Equipment. Table 8-2 is a list of descriptive factors and attributes used to develop a collateral equipment database. This list is a suggested minimum for collateral equipment maintenance management.

Facility Number	Material
Facility Title	Finish
Location	Inspection Cycle (Yrs)
Facility Component (e.g., Ceiling, Door, Floor, Flashing, Wall, Drainage, Parapet, etc.)	Inspection Checklist/Guide No.
Facility System (e.g., Exterior, Inter- rior, Roof, Tank, Fence, Grounds, etc.)	PGM Checklist/Guide No.
	Estimated Design Life (years)
	Funding Source
	Construction Date
	Condition Code

Table 8-1. Facilities Descriptive Data

8.2.2 DRAWINGS

Drawings and other graphic data are a significant portion of the physical plant information, especially for buildings, structures, utilities systems, real estate, and land improvements. They also may be a significant portion of the available information for equipment in the form of shop drawings, schematics, photographs, and assembly drawings. Drawings may exist in many forms, including paper, photographs (such as micro-film, microfiche, and aperture cards), video images, and computerized data. Computerized forms include Computer Aided Design and Drafting (CADD), Geographic Information Systems (GIS) or raster-scanned drawings. Drawings can be part of the CMMS database and linked to work orders.

Significant challenges in drawing management include keeping drawings up to date, maintaining an indexed library of drawings, and maintaining a linkage between the drawings and the systems they represent. To the maximum extent possible, Field Installations should require all drawings for new or

modified facilities and equipment to be delivered to the Government in computer readable and revisable form. However, the wholesale conversion of existing drawings to computerized form may not be practical.

8.3 DATA GATHERING

It is necessary to gather facilities and collateral equipment data to support the facilities maintenance program. The following is a suggested approach to data gathering:

8.3.1 EXISTING DATABASES

Existing databases maintained by the Field Installation provide a starting point for developing an inventory of maintainable facilities and collateral equipment items. However, databases developed for such other purposes as financial accounting will not identify all maintainable items, systems, sub-systems, and components. Further, they may include items not relevant for facilities maintenance management purposes. Using these databases as a starting point requires screening entries for inclusion in the facilities maintenance database. Where a unified

Inventory Number		Systems -
Nomenclature		Major System
Location -		Sub-System
Building		Major Component
Floor		Component
Room		Classification
Zone		Use/User
Manufacturer		Priority
Vendor/Supplier		Funding Source
Model		PM Cycle Identifiers
Serial Number		PM Guide No.
Date Acquired		Inspection Identifiers
Estimated Life		Condition Code
Cost		
Size -		
Capacity	HP	
Voltage	Weight	
Current	Dimensions	

Table 8-2. Collateral Equipment Descriptive Data

Field Installation database exists, this might take the form of flagging records as part of the facilities maintenance management program. Where the existing data is in a computerized database, it also may be possible to arrange for electronic transfer of portions of the data. This can simplify loading the data into the facilities maintenance management database. Potential existing databases include:

- NASA Real Property Database.
- Center-unique industrial, plant, personal, and minor property or collateral equipment inventory systems.

8.3.2 PHYSICAL INVENTORY

A physical inventory may be necessary to verify the data imported from other databases and to gather supplemental information to

identify maintainable items and their associated systems, sub-systems, and components not previously inventoried. Identification tags placed on collateral equipment during the inventory will help to ensure that all maintainable collateral equipment is picked up for entry into the database. Using identification tags also helps to avoid duplication.

8.3.2.1 In-house. It is possible to perform a complete physical inventory using in-house forces as part of the continuous inspection and PM programs. However, this effort may take a long time and could result in the diversion of a significant portion of the facilities maintenance work force, thereby adversely impacting routine facilities maintenance.

8.3.2.2 Contract. Contracting for the inventory is an effective method of obtaining

the data. The contract can be a separate action, in conjunction with a comprehensive condition assessment, or it can be part of the development of Maintenance Support Information (MSI). See paragraph 8.4 for more information on MSI.

8.3.2.3 Inventory Maintenance. Once developed, the facilities and collateral equipment inventory requires continuous updating to reflect additions, deletions, or changes to the physical plant. Normally, this effort is part of the preventive maintenance inspection and continuing inspection programs.

8.3.2.4 Identification Tags. Equipment identification tags should be clearly visible. Using permanent, machine-readable tags such as preprinted bar code labels eases maintenance and inventory automation and reduces the potential for data entry errors.

8.3.3 USER INFORMATION

Equipment users or custodians also are a source of inventory information as they receive new equipment or determine that equipment they already have requires maintenance. The initial identification will typically take the form of a request for equipment installation or maintenance. It can also be a response to a call for inventory assistance from the facilities maintenance organization. In either case the information provided may not be enough for facilities maintenance management purposes. A field investigation may be necessary to obtain all the maintenance information.

8.4 MAINTENANCE SUPPORT INFORMATION (MSI)

Gathering Maintenance Support Information (MSI) is a process of collecting life cycle

maintenance information on facilities and collateral equipment. Table 8-3 is a list of typical MSI. (All items listed may not apply in all cases.) Table 8-3 provides a basis for an MSI checklist.

Gathering facilities and collateral equipment MSI has historically been difficult. For new facilities and equipment, the vendor or construction contractor frequently provides the information. However, it often is not in a form or in an amount sufficient to meet facilities maintenance needs. Further, manpower is not always available to develop facilities maintenance standards and procedures based on vendor or contractor-provided information. Training provided by the contractor or vendor may or may not be adequate.

8.4.1 POLICY

The *Facilities Engineering Handbook*, (NHB 7320.1) and the *Facility Project Implementation Handbook*, (NHB 8820.2) make provision for obtaining MSI as part of the facilities project preparation and implementation process.

The following paragraphs address obtaining MSI for new facilities as part of the design process. Similar procedures apply to architect and engineering services to gather information for existing facilities.

8.4.2 PLANNING

Identifying MSI should be an integral part of the facility planning process for new facilities. Its cost should be included in budget estimates for project design. MSI should be a deliverable prepared by the design architect and engineer (A&E). MSI should be due when the facility is nearing completion,

- Operating Instructions
 - Safety Precautions
 - Operator Prestart
 - Startup, Shutdown, and Post Shutdown Procedures
 - Normal Operations
 - Emergency Operations
 - Operator Service Requirements
 - Environmental Conditions
- Preventive Maintenance
 - Lubrication, Inspection, and Adjustment Data
 - PM Plan and Schedule
- Corrective Maintenance
 - Troubleshooting Guides and Diagnostic Techniques
 - Wiring Diagrams and Control Diagrams
 - Maintenance (Including Overhaul) Procedures
 - Removal and Replacement Instructions
 - Spare Parts and Supply Lists
 - Corrective Maintenance Man-Hour Estimates
- Predictive Testing Applicability and Methods
- Other Data
 - Parts Identification
 - Warranty Information
 - Personnel Training Requirements
 - Testing Equipment and Special Tool Information
 - Contractor/Vendor Information

Table 8-3. Typical Maintenance Support Information

prior to beneficial occupancy. In this way, maintenance requirements should receive full consideration in the design process. This should result in a more easily maintained facility with full maintenance data and systems support at the time of occupancy. Guide specifications are available for developing an A&E statement of work for MSI.

Where the Field Installation lacks adequate MSI for existing facilities, especially mission critical facilities, use of an A&E con-

tract to gather MIS is recommended. This may be in combination with a condition assessment or inventory contract or as a separate contract solely for MSI.

8.4.3 PROCEDURES

While the management of A&E contracts may fall outside the responsibility of the facilities maintenance organization, the facilities maintenance organization should take an active role in developing MSI

requirements. The following paragraphs describe a typical approach to the development of MSI and the organizations responsible for the necessary actions.

8.4.3.1 Field Installation Responsibility. The Field Installation is responsible for:

- a. Identifying that a new or existing facility or equipment requires MSI and budgeting for the acquisition of MSI.
- b. Including a requirement for MSI in an A&E contract; i.e. in the design scope of work for a new facility; as part of the the scope of work for an A&E contract for condition assessment or inventory; or in the scope of work solely for MSI development. This includes identifying the level of MSI detail, submission form, and formats required from the A&E.

8.4.3.2 Joint Field Installation and A&E Responsibility. The Field Installation and the A&E should work together to identify items that require MSI.

8.4.3.3 A&E Responsibility. The A&E contractor may be tasked in their contract to provide any or all of the following items. The A&E requirements documents (and resultant contract) must reflect the project needs/deliverables in this regard.

- a. For new facilities or collateral equipment, specifying the MSI required from the construction, equipment installation, supply contractor, or equipment vendor.
- b. For existing facilities or collateral equipment, obtaining the information

directly from the manufacturers or vendors of the existing facilities and equipment.

- c. Integrating the contractor furnished information with the facility design features and use of the facility (including Field Installation operational requirements) to update the facility and equipment inventory and document appropriate maintenance standards and maintenance procedures.
- d. Assembling the MSI into the required deliverable formats.

8.4.4 DELIVERABLES

The deliverables required by the MSI specifications may take several forms. In the past, hard copies of manuals, drawings, and maintenance procedures have been the most common. However, other formats are possible. Where automated inventory and maintenance management systems are in use, the MSI acquisition should include uploading the MSI into the CMMS. Deliverables should be in computer-readable formats, including CADD and GIS drawings. MSI specifications should call for linkages between drawings, drawing components, and CMMS databases where the appropriate.

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CHAPTER 9. ENERGY CONSERVATION

9.1 INTRODUCTION

The purpose of this chapter is to familiarize facilities maintenance managers with general procedures for assessing energy use to achieve energy conservation.

9.2 PUBLICATIONS

Table 9-1 lists the NASA Headquarters publications that apply to energy conservation.

NHB 7320.1 is the basic design reference. It:

- Provides energy conservation objectives.
- Requires that Field Installations have energy management and conservation programs (EMCP).
- Encourages the use of alternate energy sources.
- Requires the use of Department of Energy (DOE) Building Energy Performance Standards (BEPS).

- Establishes fuel standards for central power plants.
- Establishes a utility metering policy.
- Provides design standards for utility systems.

The following objectives are of special concern to facilities maintenance personnel:

- Minimize energy consumption without impacting safety or operations.
- Provide utility services without waste to support mission and test objectives.
- Operate central utility plants and systems efficiently and economically.
- Make personnel aware of the importance of limiting utility use to the minimum requirements.

NHB 8820.2 specifies the procedure for submitting facility projects, including energy conservation projects.

NHB 7400.1 establishes budget cost accounts for several energy-related items

<u>Publication</u>	<u>Title</u>
NHB 7320.1	Facilities Engineering Handbook
NHB 8820.2	Facility Project Implementation Handbook
NHB 7400.1	Budget Administration Manual
NHB 7320.2	Laboratory and Industrial Ventilation

Table 9-1. NASA Headquarters Energy Conservation Publications

such as purchased utilities and fuels. It also establishes energy saving criteria and requires preparation of NASA Form 1564 (Facility Project Energy Savings Summary) for budgeting for energy saving facility projects.

NHB 7320.2 concerns the design of ventilation systems only.

9.3 POLICY

The NASA policy is to meet the requirements of the Federal Energy Management Act (1988) to reduce energy use by 10 percent by 1995 from a 1985 baseline and the Presidential goal established by Executive Order 12759 of 17 April 1991 to reduce energy consumption 20 percent by FY 2000 from an FY 1985 consumption baseline. For purposes of computation, energy consumption is measured in British Thermal Units (BTUs) per gross square foot of floor area in buildings under roof. Mission-variable energy facilities (i.e., those facilities whose energy consumption is mission-variable and which usually consume a large portion of the energy used by NASA Field Installations) are excluded. Mission-variable and non-mission-variable energy consumption are reported separately.

9.4 GENERAL

9.4.1 ENERGY AWARENESS

The key to energy conservation is energy awareness. Everyone should be made and kept aware of the high cost of energy and the significant cost reduction possible when energy is used efficiently.

9.4.2 ENERGY SOURCES

The principal energy sources for energy management purposes are:

- Electricity
- Natural Gas
- Oil
- Coal
- Renewable (solar, wind, photovoltaic, wave power, biomass, trash, methane, and geothermal)

Of these energy sources, electricity was the source of 62.3 percent of all Federal building energy used in 1988, according to the DOE "Annual Report of Federal Government Energy Management, Fiscal Year 1988" (referred to in Appendix C, reference 49). Electricity has poor energy efficiency in both generation and distribution. Also, electricity constitutes the greatest BTU equivalent and has the highest cost of common energy forms. Therefore, in energy planning and conservation, electricity should be given the most careful scrutiny.

9.4.3 STANDARDS

In 1988 DOE published Federal Building Energy Performance Standards (BEPS) that are mandatory for Federal buildings. BEPS are discussed in NHB 7320.1, *Facilities Engineering Handbook*. Their application at NASA Field Installations entails a phased approach as follows:

Step 1 Conduct an energy audit to compare building energy efficiency with the DOE standard applicable to the local climate.

Step 2 Identify potential energy-saving retrofit measures and analyze net

benefits throughout the projected building life cycle; prioritize the measures based upon the projected savings-to-investment ratio (SIR).

Step 3 Prepare a retrofit plan, including facilities projects.

Naval Facilities Engineering Command (NAVFAC) Instruction 11300.37 (Appendix C, reference 50) has also published the BEPS. BEPS provides standards in the following categories:

- Facilities Operation.
- Comfort Heating and Cooling
 - Housing and Administrative Spaces.
- Cooling.
- Heating.
 - Laboratories, Shops, Warehouses.
- Domestic Hot Water Temperatures.
- Interior Lighting
 - Administrative Areas.
 - Utility Rooms.
 - High Bay Areas.
- Exterior Lighting.
- Heating, Ventilating, and Air Conditioning.
 - Air Handling Units.
 - Air Ducts.
 - Chilled Water Systems.
 - Controls.
- Steam and Hot Water Systems in Buildings.
- Weatherization
 - Cooled Buildings.
 - Heated Buildings.

9.4.4 LIFE-CYCLE COSTING

Life-cycle costing is the primary tool for analyzing energy retrofit projects. It consid-

ers all relevant costs. The data can be combined in four ways to evaluate economic performance:

- a. Total Life Cycle Cost. The sum of all significant dollar costs discounted to present value.
- b. Net Life-Cycle Savings. The decrease in total life-cycle cost attributable to an energy conservation project.
- c. Savings-to-Investment Ratio. A numerical ratio comparing the projected reduction in energy costs (net of increased non-fuel operation and maintenance costs) to the estimated increase in investment cost, minus increased salvage values.
- d. Payback Period. The elapsed time between the initial investment and the time at which cumulative savings in energy costs, net of other future costs, are just sufficient to offset the initial investment cost.

Each parameter has a different application. For example, total life-cycle cost is best for choosing among alternative designs for a new building, whereas savings-to-investment ratio is best for ranking retrofit projects.

9.4.5 COGENERATION

Cogeneration is a method of producing two forms of energy from one primary source such as coal, oil, or natural gas. The primary energy produced is usually electricity. The secondary energy form produced is normally thermal energy used for space and water heating and/or air conditioning.

DOE estimates that a 10-30 percent reduction in fuel requirements is possible through cogeneration. An annual return on investment of about 20 percent can be expected. For most cogeneration systems, an average simple pay-back of 2 to 4 years is achieved. Field Installations that generate steam or hot water should investigate cogeneration.

9.5 ENERGY USE ASSESSMENT

A successful energy management program depends upon several factors:

- Establishing an energy management team.
- Analyzing utility billing records.
- Screening for energy efficiency opportunities.
- Identifying energy conservation opportunities.
- Analyzing energy conservation opportunities.

The last three are discussed below.

9.5.1 SCREENING FOR ENERGY- SAVING OPPORTUNITIES

Large, immediate energy cost savings involving no capital investment can be achieved by the following methods:

- Promoting energy awareness.
- Rescheduling operating hours to take advantage of off-peak rates or increased daylight hours.
- Rescheduling major energy consuming operations; for example, scheduling wind tunnel tests at night to take advantage of night rates.
- Reducing lighting intensity, amount of area lighted, and amount of time lights are operated hours.

Longer term savings require energy audits. Audits identify facility characteristics. There are basically three types of energy audits:

- Preliminary or Walk-Through Audits.
- Building/System Audits.
- End-Use/Equipment Audits.

Each is discussed below. There are many commercial firms that perform energy audits by contract.

9.5.1.1 Preliminary Audits. These audits collect overall facility information, collect major energy-using systems/equipment information, identify the types of systems/equipment in each building, and collect energy billing data.

9.5.1.2 Building/System Audits. After gathering preliminary audit data, one must decide whether to proceed to the next audit step, the building or system audit, which is usually done by a professional energy audit company. The information gathered during a building or system audit is used to model building or system energy use and to identify energy conservation opportunities. The model should serve to quantify the effects of implementing the various energy conservation opportunities identified.

The information gathered during a building audit falls into five data categories, as follows:

a. Building envelope/shell data:

- Floor area.
- Number of zones and zone identification.
- Area by zone.

- Windows.
 - Doors.
- b. Heating, ventilating, and air conditioning data:
- System manufacturers.
 - System types.
 - Zone assignments to systems.
 - Heat sources for systems.
 - Cooling sources for systems.
- c. Lighting and electrical systems data:
- Lighting levels (watts/sq.ft., foot candles).
 - Control scheme for lights.
 - Locations of fixtures.
- d. Central utility plant systems data:
- Boiler specifications (fuel usage, etc.).
 - Cooling plant specifications.
 - Cooling tower specifications.
 - Domestic water specifications.
- e. Weather data (daily and monthly averages):
- Air temperature.
 - Relative humidity.
 - Wind speed.
 - Wind direction.

9.5.1.3 End-Use/Equipment Audits. This final audit step should be taken only if a building/system audit shows the need for more detailed information or for the analysis of one or more specific energy conservation opportunities.

9.5.1.4 Operations and Maintenance Energy Services (OMES). The U.S. Navy has

developed a contracting approach that saves energy quickly and simply. It is called Operations and Maintenance Energy Services (OMES). It is described in *Naval Facilities Engineering Command OMES Generic Solicitation* (Appendix C, reference 51).

OMES is a fixed price, indefinite quantity delivery order contract that is fast and flexible. The contract is awarded based on an evaluation of technical and price proposals. Technical proposals include the qualifications of contractor personnel and their related business experience. Price proposals are based on a Government schedule that includes line item prices for energy audits and/or steam trap surveys and hourly labor rates and contractor prices to furnish and install specified hardware items such as lighting retrofits, programmable thermostats, steam traps, etc.

OMES contracts are executed incrementally. For example, the contractor may be given \$10,000 to \$20,000 to conduct an energy audit and/or a steam trap survey. The contractor may be tasked to identify energy conservation projects with a simple payback of two years or less. The Government selects which projects the contractor implements. The Government then may direct the contractor to implement the selected projects.

Contractors are enthusiastic about OMES because it emphasizes quick payback projects and allows for innovation.

9.5.2 IDENTIFYING ENERGY CONSERVATION OPPORTUNITIES

The most common energy conservation opportunities fall into the following nine categories:

- Building Equipment Operation.
- HVAC Generation Systems.
- HVAC Distribution Systems.
- Water Heating Systems.
- Lighting Systems.
- Power Systems.
- Heat Recovery/Reclaim Systems.
- Utility Control Systems (UCS).
- Building Envelope.

More complete descriptions of these individual opportunities are contained in the *Architect's and Engineer's Guide to Energy Conservation in Existing Buildings* (Appendix C, reference 49).

Often the biggest and fastest energy consumption savings are achieved by changing policies and procedures at no cost or by making small facilities or equipment investments within local funding authority. Appendix I is a checklist of such actions. Implementation details for each of the energy conservation opportunities in the checklist are contained in the *Architect's and Engineer's Guide to Energy Conservation in Existing Buildings* (Volume 2).

9.5.3 ANALYZING ENERGY CONSERVATION OPPORTUNITIES

The two principal variables in an energy analysis are the rate of energy use per unit of time and a time factor. While some calculations are simple, others vary in a

complex fashion over time. For this reason, a computerized energy model using automated calculation methods is recommended. The advantage of using computer models is that a number of calculations can be run quickly and conveniently using various combinations of the following parameters to determine the sensitivity of the facility's energy use to each parameter:

- Insulation and fenestration.
- Weather impact.
- Full and part load equipment performance.
- Variable interactions, e.g., the effects of varying internal lighting reductions on heating and cooling loads.

There are many computer programs available commercially to make building energy analyses. Because of the large number of programs available and the rapid advances in the technology, no specific programs are mentioned here.

In the course of analyzing energy conservation opportunities, if it appears that a facility project will be required, sufficient information must be developed to fill out NASA Form 1564, Facility Project - Energy Savings Summary.

9.6 ENERGY-USE REDUCTION SYSTEMS

Two of the commercial energy-saving systems coming into wide use are utility control systems and heat recovery/reclaim systems. They are described below.

9.6.1 UTILITY CONTROL SYSTEMS (UCS)

A UCS saves energy by efficiently controlling heating, ventilating, air conditioning, lighting, and other energy-consuming equipment. It selects optimum equipment operating times and set points as a function of electrical demand, time, weather conditions, occupancy, and heating and cooling requirements. Rising energy costs and decreasing computer prices have encouraged the use of UCS. The basic UCS control principles are to:

- Operate equipment only when needed.
- Eliminate or minimize simultaneous heating and cooling.
- Supply heating and cooling from the most efficient source.
- Supply heating and cooling according to actual need.

Using a system to provide control of the air handlers, pumps, chillers, and the other systems can result in simpler control circuits.

In non-computerized systems, when it is desired to change the operation of equipment, separate relays and wiring can be installed for every control option. If, for example, an air handler is to be controlled by timeclock, override timer, temperature of a room, etc., each of these controls requires separate relays and wiring. The wiring schematics, even if they are up-to-date, get complex and the field wiring confusing. Using computerized control, all pieces of equipment have a single control relay. All the sequencing, timing, and scheduling are controlled by software. The control schematics and field wiring become simple and

easy to troubleshoot. In addition, a standardized design can be used for the installation of new control circuits. If the control sequences or the type of control needs to be modified, it can be done by a modification to the software. In most cases, no hardware modifications are required.

UCS can aid in troubleshooting. In a computer controlled building, maintenance personnel use the computer to provide an initial evaluation prior to visiting the site to evaluate a problem. For example, in responding to hot and cold calls, the maintenance technician can first examine the area of the complaint on the computer screen in an attempt to identify the source of the problem. In some cases the minimum air flow and the setpoint temperatures can be adjusted on the computer and no visit to the site is required. In other cases, the computer can be used to identify the source of the problem and the technician can go directly to the site of the problem. This saves time as compared with the old method of troubleshooting that involved first visiting the site, then manually evaluating the possible causes of the problem.

UCS can aid in PM. Most systems have the ability to monitor equipment run-times. The run-times can then be used to identify PM requirements. UCS can also provide a positive indication of equipment status so that equipment not operating properly or a dirty filter can be identified and repaired or replaced.

Many UCS also have a PM module to generate work orders and procedures for PM tasks.

9.6.2 HEAT RECOVERY/ RECLAIM SYSTEMS

These systems reclaim and reuse heat energy that would otherwise be rejected from the building. The effectiveness of a heat reclaim system depends upon the quantity and temperature of heat reclaimed and the application of the reclaimed heat.

9.7 UTILITY SYSTEMS

The primary energy-consuming systems that require close management are:

- Heating and Power Plants.
- Steam Distribution Systems.
- Hot Water Distribution Systems.
- Electrical Distribution Systems.
- Compressed Air Systems.

9.7.1 UTILITIES MANAGEMENT

Because utilities systems are major consumers of energy, discussion of utilities management is included here in some detail. At the Center level, there are four major functions of utilities management. These are:

- a. System Development. This includes the design or planned improvement of generation, distribution, and collection facilities to achieve efficient and economical system operation.
- b. Operations and Distribution. These are directed toward maximizing the efficiency of production, distribution, and collection equipment using minimum manpower and materials.

- c. Inspection and Maintenance. These are directed toward minimizing system down-time at minimum cost.

- d. Usage Control. This is directed toward minimizing waste.

Effective utilities management consists of applying the four basic management elements (planning, organizing, directing, and controlling) to the above four functional areas. Figure 9-1 may be useful in that regard.

Because electricity normally accounts for about 60 percent of utilities costs and steam about 30 percent, some information is included here about general utilities requirements planning and electrical and steam system operations and maintenance.

9.7.2 REQUIREMENTS PLANNING

Utilities requirements are based upon population; square footage of space to be lighted, heated, and air conditioned; and specific industrial uses. Norms can be developed if historical facilities, weather, and usage data are available. Usage data can be obtained from operating logs, metering surveys, or engineering estimates. Utilities requirements can then be compared with existing capabilities to identify shortfalls or alternative sources. To determine system capabilities, system capacities can be calculated for each unit of generation or production and for each segment of the related distribution losses, inefficiencies, and waste should be accounted for during this process. An analysis should then be made of existing load characteristics such as load per year, month, week, day, or season. Peak loading and duration of peaks are key factors.

9.7.2.1 Charting. Charting is one method of determining when projected requirements exceed existing capacities. Charting is useful to determine over-capacities, or when utility requirements are diminishing due to mission changes, closure, or retrenchments. The primary reason for charting is to identify peak demand, which is a large factor in determining commercial rates, especially for electricity.

9.7.2.2 Alternatives. Before action is taken to alleviate a peak condition through a supplementary source (assuming an increased requirement), other alternatives should be examined. Examples are:

- Review projected peaks to assure validity.
- Investigate rescheduling or shifting individual loads to ease peak loads and flatten the demand curve.
- Investigate no cost/low cost actions to reduce waste and distribution losses.
- Investigate improving system efficiency to absorb the peak load without a supplementary source.

The following questions concerning the peak load problem should also be asked:

- Do Field Installation facilities warrant an increase in capacity by means of additional production capabilities?
- Can the service be purchased to absorb the peak load?
- If additional capacity is provided in-house, can excess capacity be sold to the local utility company?
- Have all energy conservation projects been accomplished?

9.7.3 GENERAL OPERATIONAL CONSIDERATIONS

In order to provide reliable, high quality, economical utilities service, utilities management should:

- Maintain equipment and distribution systems in top working order.
- Have proper staffing to operate the systems.
- Schedule the equipment and manpower for appropriate needs.

Standard operating procedures should be developed to cover routine operations, start-up and shutdown, operator maintenance, preventive maintenance, and emergency actions, such as load-shedding plans, emergency customer notification, and local utility company coordination. Contingency plans should be developed, kept current, and exercised periodically to:

- Identify and use available emergency generation units.
- Identify and use interconnections and isolation points in service lines.
- Identify and correct sources of outages.
- Prioritize restoration of services in order of importance.

9.7.4 METERS

Meters should be installed in accordance with the metering policy set forth in NHB 7320.1, which covers electric, steam, gas, water, liquid fuel, and transportation fuel metering.

Basic Elements and Major Functions of Utilities Management			
<u>Basic Elements of Management</u>	<u>System Development</u>	<u>Operations and Distribution</u>	<u>Inspection and Maintenance</u> <u>Usage Control</u>
Planning	Determining short and long range utilities requirements, evaluating alternative system improvements, and deciding upon the best available course of action.	Scheduling equipment, manpower, and material to most economically meet varying short-range requirements.	Determining inspection procedures and frequencies based on operational needs, required maintenance levels, and inspection and maintenance schedules consistent with operations requirements. Identifying waste, developing procedures for curtailment, and setting saving targets.
Organizing	Assigning planning responsibility, bringing necessary skills to bear on the technical aspects of system planning, and coordinating technical and economic considerations.	Delegating operational responsibilities to levels where numerous decisions can be made competently and conveniently on a frequent, routine basis.	Assigning principal responsibility for determining maintenance needs to utilities division head, who is also accountable for operations, and otherwise adopting flexible assignment practices to maximize use of special skills. Establishing usage control committees in each operating department and assigning skilled engineering or maintenance personnel to provide technical assistance as required.
Directing	Conducting installation of system improvements as planned.	Instructing, training, and assigning personnel to carry out required duties for economically meeting generation and distribution requirements.	Implementing planned inspection and maintenance schedules. Assigning key line personnel to carry out planned procedures and achieve established targets.
Controlling	Reviewing special reports of installation progress against plan, surveying peak demand behavior in relation to design capacity, monitoring cost trends, investigating outages, and taking corrective action.	Comparing scheduling performance and equipment efficiencies with established norms, monitoring characteristics recorded in data logs on a continuing basis, and taking corrective action.	Analyzing reported accomplishment against target commitments in terms of both action taken and savings attained, and initiating corrective action.

Source: Naval Facilities Engineering Command
Instruction 11300.37 of 12 June 1989

Figure 9-1. Basic Elements and Major Functions of Utilities Management

9.7.5 ELECTRICAL OPERATIONS

There are various options for obtaining electrical power, for example:

- Purchased all power.
- Purchased primary power and Field Installation standby generators for emergencies and peak demands.
- Generate primary power and purchase standby power.

The considerations are:

- How much electricity to purchase?
- How much electricity to generate?
- How should available electrical generation equipment be scheduled to meet the demand?

Effective electricity management considers capacity, quality, efficiency, readiness, sustainability, and economy. For purchased electricity, the manager should know what factors are integrated into the local utility rate structure. This may include the relationship between the peak and demand rates, penalty clauses, peak hours, and the time period during which the peak is measured.

9.7.5.1 Equipment Scheduling. Equipment scheduling is the key to controlling electrical power costs. Several factors influence scheduling:

- a. Cost Curves for Generating Electricity. Unit cost curves should be developed to include fuel or steam, direct and indirect labor, and maintenance and operating supplies.
- b. Demand Curves. Constantly updated hourly minimum and maximum demand curves, with seasonal

curves, should be generated as a normal part of daily operations.

- c. Loading Factors. The loading schedule should be developed based upon the cost and demand curves.
- d. Monitoring. Daily production and the actual loading factor should be plotted on the same chart as the ideal loading factor. If the actual loading factor does not fall between the ideal maximum and minimum loading factors, the cause should be investigated.
- e. Operating Logs. Operating logs should be maintained to provide data to evaluate equipment, personnel, and trends.

9.7.5.2 Other Considerations. Distribution system operations are concerned with ensuring that adequate capacity and quality are available to users. Single-line drawings should be prepared to show the locations of distribution transformers, relays, disconnects and meters, and load-shedding sequence. Two useful publications in this regard are published by the Naval Facilities Engineering Command; i.e., (NAVFAC) MO-204, *Electric Power System Analysis*, and NAVFAC MO 201, *Operation of Electrical Power Distribution Systems*.

9.7.5.3 System Checks. There are several system checks that indicate system performance. These are described below. Each has a direct bearing on electrical power costs:

- a. Demand Factor. The ratio of the maximum demand to the total con-

nected load. An acceptable range is 0.7 to 0.8.

- b. Load Factor. The ratio of the average demand over a given period of time to the peak demand during the same period. An acceptable range is 0.65 to 0.75.
- c. Transformer Loss. The ratio of the installed distribution transformer capacity to the peak demand. Normally, installed capacity should be no more than 2 to 2-1/2 times peak demand. A high ratio results in excessive losses.
- d. Voltage Regulation. Under normal operating conditions, a voltage regulation of plus or minus 5 percent is acceptable.
- e. Power Factor. Power factor is the relationship of the phases of the current to the voltage of the AC electrical system. If the current and voltage are in phase, the power factor is 1.0. A power factor in the range of 0.85 to 0.95 is considered good. Low power factor can be improved using synchronous motors or by installing capacitor banks in the feeder lines.

9.7.6 STEAM OPERATIONS

Steam operations require control of the following functions:

- Equipment Scheduling. Matches generation with load.
- Equipment Operation. Achieves operating efficiency at operating loads.

- Distribution System Operation. Reduces line losses.

Each is discussed below.

9.7.6.1 Equipment Scheduling. Equipment scheduling requires knowledge of demand curves, unit cost curves (with selection of single boiler operation and multiboiler operation), banking and start-up costs, loading factors, and monitoring of both equipment selection and scheduling.

9.7.6.2 Equipment Operation. Equipment operation depends upon boiler logs to form the basis for boiler performance analysis to achieve steam production at the lowest cost. Weather data, stack temperature, feed water data, steam quantities, pressures and temperatures, and carbon dioxide and oxygen readings should be recorded hourly. The optimum thermal efficiency curve for each unit should be obtained from the boiler manufacturer. NAVFAC MO-209, *Maintenance of Steam, Hot Water, and Compressed Air Distribution Systems*, provides detailed information on the operation and maintenance of steam distribution systems.

9.7.6.3 Distribution System Operation. Distribution system operation should concentrate on reducing line losses between the boiler and the point of steam use and reducing the steam demand. A single-line drawing should be maintained to show the location of all shut-off valves, pressure-reducing stations, traps, meters, and condensate return pumps and lines. Temporary meters should be used where permanent meters are not installed.

9.8 SIMULATION METHODS

A building simulation is a mathematical representation of the way in which a building functions. The accuracy of the simulation is determined by the validity of the assumptions upon which the simulation is based. The reasons for building simulations are:

- To conduct research on building behavior.
- To design new buildings.
- To size building systems or components.
- To retrofit existing buildings.
- To market building systems and components.

Building energy use simulation models are classified by the type of analysis and the type of calculations they perform. The types of analysis follow:

- Whole Building Analysis.
- Component Analysis.
- Parametric and Sensitivity Analyses.
- Retrofit Analysis.

Calculations are classified by the time step used; i.e., static, incremental, and dynamic. Detailed use of simulations is explained in the DOE Guide *Architect's and Engineer's Guide to Energy Conservation in Existing Buildings*. Because the technology and products available commercially are developing so rapidly, more detailed discussion is inappropriate in this handbook. Field Installations are encouraged to investigate new programs with local software vendors.

9.9 SHARED ENERGY SAVINGS (SES) CONTRACTS

Under the Shared Energy Savings contracting method, the contractor incurs the costs of implementing energy savings measures, including the cost of energy audits, acquiring and installing equipment, and training personnel. The contractor is given a share of the energy savings resulting directly from implementing such measures during the term of the contract. Authority for shared energy savings contracts is provided by 42 U.S.C. 8287, the National Energy Conservation Policy Act as amended, and by the 1988 Federal Energy Management Improvement Act. The latter act has a large impact because it requires that each Federal agency establish a program of incentives for conserving and otherwise making more efficient use of energy by entering into SES contracts. A major benefit of the program is that Field Installations can use energy savings for additional energy conservation measures. There are two significant advantages of these contracts.

- No up-front Government funding is required. By law, all payments to the contractor are made from annual building operating funds. Hence, there is no long approval period or uncertainty.
- The technical and economic risks to the Government are small because the contractor provides both the technical knowledge and funds.

SES contracts are discussed in more detail in the DOE *Architect's and Engineer's Guide to Energy Conservation in Existing Buildings*, and in NAVFAC Instruction 11300.37, "Energy and Utilities Policy." It is recommended that Field Installation facilities

maintenance personnel investigate the use of SES contracts.

9.10 PEAK SHAVING

One method of reducing electrical energy costs, and possibly reducing energy consumption, is to enter into a peak shaving contract with the public utility. Under such an arrangement, the Field Installation agrees to reduce its peak load by a specified amount, and the public utility agrees to reduce the utility rate for such peak shaving. The Wallops Flight Facility (WFF) has such a contract. Under the contract, WFF agrees to reduce its peak load by 750-KW when so requested by the public utility. The 750 KW load reduction can be achieved by load-shedding, by bringing a 750-KW generator on line, or by a combination of these methods. WFF expects to implement peak shaving up to 20 times per year at an annual saving of about \$30,000 (FY91).

The following are the advantages of peak shaving contracts. The customer:

- Avoids brown-outs.
- Regularly exercises his load-shedding plan.
- Exercises his emergency generators.
- Reduces his electric power costs.

9.11 BUDGETING

Energy conservation funds are included in routine Field Installation operations and maintenance budgets. There are no funds dedicated to energy conservation projects at the NASA Headquarters level.

If an energy conservation project is of facility project scope, it must be submitted in accordance with NHB 8820.2. NHB 8820.2

requires that a NASA Form 1564 (Facility Project - Energy Savings Summary) be submitted to NASA Headquarters with the annual budget submission. NHB 7400.1, *Budget Administration Manual*, lists the criteria that must be met by energy facility projects.

PART III

INFORMATION

Part III contains general facilities maintenance information that may be useful in understanding Parts I and II. It also provides background on programs in which the facilities maintenance organization has an interest but for which it does not have primary responsibility.

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CHAPTER 10. FACILITIES MAINTENANCE FUNCTIONS

10.1 INTRODUCTION

This chapter amplifies the concepts presented in Chapter 3. It introduces the functions covering or closely related to facilities maintenance management that are recommended for use within NASA.

The facilities maintenance model depends on a number of interrelated functions and processes that directly or indirectly lead to or support the accomplishment of facilities maintenance work. Certain of these are not the responsibility of the facilities maintenance organization, particularly when the scope of work requires or the best solution exceeds specified Field Installation funding or resource thresholds; for example, when the work is of Construction of Facilities (CoF) project scope. Other functions may be assigned to a different organization at the Field Installation. They are included with the facilities maintenance organization's functions below for informational purposes.

Managing facilities encompasses all actions required to for the acquisition, maintenance, repair, alteration, improvement, modification, use, and disposal of facilities and maintainable collateral equipment. It includes buildings, grounds, structures, roads, airfields, utility systems, and waterfront structures. It does not include administrative equipment. The principal processes involved are to:

- Plan for facilities and collateral equipment.
- Maintain facilities and collateral equipment.
- Provide utilities services.

- Maintain environmental quality.
- Employ contracts.
- Manage material and tools.
- Provide management support.
- Provide mobile equipment.
- Develop budgets and performing cost analyses.

Each is discussed below.

10.2 PLAN FOR FACILITIES AND COLLATERAL EQUIPMENT LIFE CYCLE

Planning involves those portions of the facilities and collateral equipment life cycle normally associated with acquisition and disposal. Except for developing facilities maintenance plans, such planning is not done by the facilities maintenance organization and is, therefore, beyond the scope of this handbook. However, close coordination, including the exchange of status information, among the facilities planners, the facilities engineers, and the facilities maintenance managers is necessary for a successful facilities maintenance program. NHB 7320.1, *Facilities Engineering Handbook* and NHB 8820.2, *Facility Project Implementation Handbook* are primary references for these functions. The life-cycle planning processes include:

- Identifying present and future facilities requirements.
- Evaluating existing assets against planned requirements.
- Developing acquisition and disposal plans and programs.
- Developing projects.

- Developing facilities maintenance, alteration, and improvement plans.
- Preparing comparative cost evaluations.

10.3 MAINTAIN FACILITIES AND COLLATERAL EQUIPMENT

Maintaining facilities and collateral equipment is the heart of the facilities maintenance mission and is the primary focus of this handbook. It covers caring for existing facilities and includes activities to accomplish the following:

- Scheduling the inspection of facilities and collateral equipment.
- Inspecting facilities and collateral equipment.
- Receiving and documenting work to be performed.
- Controlling work.
- Preparing work packages.
- Gathering resources and scheduling work accomplishment.
- Executing work.
- Evaluating work.
- Developing, maintaining, and analyzing management information.
- Maintaining a technical library of written and graphic facilities information.

10.4 PROVIDE UTILITIES SERVICES

This major functional area addresses providing utilities services to customers, including steam and other forms of thermal energy, electricity, natural gas, water, sewage and waste treatment, compressed air, chilled water, and other common services. It includes actions to:

- Acquire fuels and purchase utilities.
- Produce utility commodities.
- Deliver utility commodities.
- Administer utility distribution.

10.4.1 ACQUIRE FUELS AND PURCHASE UTILITIES

This function includes establishing requirements for, coordinating the purchase and receipt of, and managing inventories of bulk fuels and utilities. The processes are:

- Determining fuels and purchased utilities requirements.
- Placing orders against existing contracts.
- Verifying the receipt of fuels and purchased utilities.
- Forwarding contract certifications to the Comptroller or Contracting Officer.
- Managing the fuel inventory.

10.4.2 PRODUCE UTILITY COMMODITIES

This function involves operating central utility plants, including plant operator maintenance, through the following processes:

- Operating the plants.
- Managing plant operations.
- Coordinating plant operations and purchased utilities services.
- Managing operator maintenance of utility plant equipment.

10.4.3 DELIVER UTILITY COMMODITIES

This function involves operating utility distribution systems, including piping and

wiring systems, through the following processes:

- Managing scheduled and unscheduled outages.
- Establishing temporary customer connections.
- Adjusting distribution system components.
- Developing and executing contingency plans.
- Monitoring the quality of delivered commodities.
- Locating utility lines.

10.4.4 ADMINISTER UTILITY DISTRIBUTION

This function includes collecting consumption data and covers the following activities:

- Calibrating metering equipment and managing configuration changes.
- Determining commodities usage for each billing period.
- Preparing and analyzing utility cost reports.
- Aiding in the development of utility rates.
- Assigning utility charges to the using organizations.
- Billing and following-up on billings to ensure prompt payment.

10.5 MAINTAIN ENVIRONMENTAL QUALITY

Field Installations must comply with Federal, state, and local requirements. Compliance includes the following:

- Knowing the regulations.

- Identifying pertinent compliance requirements.
- Training affected facilities maintenance personnel to comply with the requirements.
- Coordinating with local environmental officials and inspection teams.

This function primarily involves information gathering and training to support facilities maintenance-related work.

10.6 USE OF CONTRACTS

Facilities maintenance is a major user of contracts, particularly support services contracts. The general contract process involves the following major functions:

- Organizing the procurement team.
- Developing the contract schedule.
- Performing the needs analysis.
- Developing the procurement plan.
- Writing the statement of work.
- Selecting the contract type.
- Writing the quality assurance plan.
- Preparing the contract documents.
- Soliciting bids/proposals.
- Evaluating bids/proposals.
- Awarding the contract.
- Administering the contract.

The extent of the facilities maintenance organization's involvement in the process depends upon the desires of the Contracting Officer. However, at a minimum, the facilities maintenance organization should have a major role in writing the statement of work and in assisting with contract administration. A brief description of these two functions follows.

10.6.1 STATEMENT OF WORK (SOW)

The SOW is a definitive description of the product or service obtained under the contract, usually expressed in words. Clear and explicit requirements in SOW will increase the likelihood of receiving high quality bids or proposals and contractor performance. Care exercised in writing the SOW establishes a solid baseline for proposal technical evaluation and for measuring contractor effectiveness. Support services contracts typically call the SOW a performance work statement (PWS). The following are suggestions for SOW preparation.

10.6.1.1 Considerations. There are several elements to consider in preparing a SOW. They are:

- General scope of work (contract objective).
- Contractor tasks.
- Contract end items.
- References (related studies, specifications, etc.).
- Data requirements.
- Support equipment.
- Government-furnished property, facilities, equipment, utilities, data, services, etc.
- Schedule or performance period.

10.6.1.2 Language. SOW's are read and interpreted by people with many backgrounds and professional interests (engineers, architects, lawyers, contractors, accountants, etc.). The language must be precise and must use standard contract terms. The language must:

- Use active rather than passive verbs, the object of which is a tangible or

concrete item, if possible. For example, correct terms are "provide, manufacture, or submit."

- Avoid the ambiguity created by such words or phrases as "and/or", "or equal", and "generally accepted."

10.6.1.3 Checklist. The following are some suggested questions for checking a completed SOW:

- Can both the Government and the contractor accurately estimate the resources required?
- Can both the Government and the contractor measure the product so they understand the requirement and criteria for satisfactory completion?
- Is it clear what the contractor "shall" do and what the Government "will" do?
- Are the quality assurance measurements fully spelled out?
- Are proven, standard references or specifications cited rather than new, untested ones developed specifically for the contract?
- Are standard specifications cited when they are not appropriate?
- Is the completion date clearly specified? Is the elapsed time expressed in calendar days or work days?
- Are the options and option periods clearly spelled out?
- Are the data requirements clearly tied to the options?
- Is the SOW so restrictive that only one contractor can bid, thus creating a sole source situation?
- Are extraneous data requirements specified?
- Are there ambiguities which could cause contractors to bid high to

cover contingencies or create disputes during contract performance?

- Is the method of payment (partial payment or progress payment) appropriate for the contract?
- Does the SOW contain proprietary requirements which could limit competition or cause licensing problems?
- Does the SOW tell the contractor how to perform the work (prescriptive specification) or describe the product (performance specification)? The latter permits the contractor to determine his own methods while the former specifies the "how to" and restricts contractor initiative.

10.6.1.4 Sources. Table 10-1 lists facilities-related guide performance work statements available from the Department of Defense.

10.6.1.5 Preparation Guide. The Department of Defense publishes Military Handbook (MIL-HDBK) 245B titled *Preparation of Statement of Work*. It is a detailed guide for SOW preparation for all types of Federal Government contracts.

10.6.2 CONTRACT ADMINISTRATION

Actions required after contract award include the following:

- Holding the post award conference.
- Processing orders against the contract.
- Modifying the contract.
- Conducting contract surveillance.
- Evaluating contractor performance.
- Calculating and processing contract payments.

- Closing out the contract.

Normally, the Contracting Officer will assign the Contracting Officer's Technical Representative (COTR) responsibilities for facilities maintenance support services contracts to an individual in the facilities maintenance organization. The primary COTR responsibilities are conducting surveillance for quality assurance and evaluating the contractor's performance.

10.7 MANAGE MATERIAL AND TOOLS

Managing material (defined as items used in the performance of facilities maintenance work) includes procuring and receiving materials, ensuring accountability and control of inventories, and distributing and disposing of material. For tools, this function includes receiving, issuing, and disposing of centrally managed or controlled tools and maintaining custodial records of tools.

10.7.1 FORECAST, ACQUIRE, AND DISPOSE OF MATERIAL

The following processes ensure that the proper quantities and types of material are available and ready for use:

- Establishing and updating stock levels and reorder limits.
- Requisitioning or purchasing material.
- Receiving material.
- Disposing of material.

10.7.2 CONTROL MATERIAL

These processes maintain accountability for material. They include:

1. Buildings and Structures
2. Bus Services
3. Central Heating Plant and Distribution Systems Operation, Repair, and Maintenance
4. Custodial Services
5. Electric Power Generation, Heating Plant and Steam Distribution System Operation, Maintenance, and Repair
6. Elevator Maintenance Services
7. Maintenance and Repair of Fixed Protection and Alarm Systems
8. Grounds Maintenance Services
9. Guard Services
10. Hazardous Waste Management Services
11. Heating, Ventilating, and Air Conditioning (HVAC), Refrigeration, and Compressed Air Systems Operation, Maintenance, and Repair
12. Hospital Housekeeping Services
13. Maintenance of Military Family Housing
14. Operation and Maintenance of Electrical Distribution and Emergency Generation Systems
15. Multi-Function Service
16. Pest Control Services
17. Rail Facilities Maintenance and Repair
18. Solid Waste Collection and Disposal
19. Surfaced Areas Maintenance
20. Operation of Telephone/Communications Systems
21. Transportation Operation and Maintenance
22. Wastewater Collection Systems and Treatment Facilities, Operation and Maintenance
23. Water Plants and Systems Operation and Maintenance

Table 10-1. List of Facilities-related Guide Performance Work Statements

- Storing and safeguarding material.
- Issuing material against approved work orders.

10.7.3 ACQUIRE AND DISPOSE OF TOOLS

The following processes ensure that the proper tools are available to support facilities maintenance tasks:

- Determining the type and quantity of tools required.
- Requisitioning or purchasing tools.
- Receiving tools.
- Disposing of tools.

10.7.4 CONTROL TOOLS

The following processes maintain accountability for tools:

- Issuing tools to the mechanics.
- Maintaining tools.
- Maintaining tool checkout/accountability records.
- Accepting returned tools from the mechanics.

10.8 PROVIDE MANAGEMENT SUPPORT

Management support includes office services and administrative support, technical information control, capital asset tracking, safety, human resources management, and planning for these services. Although the facilities maintenance organization staff performs many of these activities, they are outside the scope of this handbook. They affect organizational structure and should receive consideration when developing a maintenance organization. This function encompasses the following activities:

- Documenting time and labor charges.
- Maintaining publications such as instructions, and handbooks.
- Maintaining the library of technical documents.

10.9 PROVIDE MOBILE EQUIPMENT

This function provides construction and materials handling equipment to support the Field Installation facilities maintenance functions. It includes managing materials handling equipment such as cranes and forklifts, construction equipment such as road graders or backhoes, grounds maintenance equip-

ment such as bush hogs and gang mowers, and railroad equipment. Testing and certifying weight and materials handling equipment are especially important. Although most of this function is not normally the responsibility of the facilities maintenance organization, it is a key supporting function.

10.10 DEVELOP BUDGETS AND PERFORM COST ANALYSES

This function includes planning, programming, budgeting, expending, and reviewing the financial resources of the facilities maintenance organization. It involves prioritizing funding requirements, allocating resources, monitoring costs, reviewing expenditures, and analyzing financial status. Chapter 2 discusses financial and budget systems. Chapter 4 provides information on Annual Work Plans, the basis for budget estimates.

10.10.1 PLAN FUNDING REQUIREMENTS

The following tasks support the development of the Facilities Maintenance Five-year Facilities Maintenance Plan within a long-range planning framework:

- Preparing the long-range financial plan.
- Reviewing funding requirements.
- Reviewing historical and projected resource levels.
- Determining surpluses or deficiencies.
- Preparing financial documentation.

10.10.2 PROGRAM REQUIREMENTS AND ALLOCATE RESOURCES

The following tasks translate the Five-year Facilities Maintenance Plan and other constraints into the Annual Work Plan. They include:

- Preparing and submitting Institutional Operating Plans (IOP's)/Program Operating Plans (POP's).
- Prioritizing funding requirements and resources.
- Allocating resources.

10.10.3 PREPARE BUDGET

The budgeting process communicates Field Installation requirements and plans to external offices, including NASA Headquarters. The budget process includes:

- Receiving budget guidance.
- Finalizing resource requirements.
- Preparing detailed expense operating budget plans.
- Determining unfunded requirements.
- Submitting budget documents.

10.10.4 EXECUTE EXPENSE OPERATING BUDGET

The following tasks are associated with budget execution and workload management.

- Receiving funding authority (allotments/warrants).
- Issuing work authorizations and payments.
- Performing internal cost tracking.

10.10.5 REVIEW EXPENDITURES AND ANALYZE RESOURCE STATUS

The following tasks comprise financial review, analysis, and control. They facilitate evaluation and redirection of financial resources when appropriate. They are:

- Reviewing expenditures.
- Analyzing financial reports.
- Initiating corrective actions.
- Preparing reports for higher authority.

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CHAPTER 11. RESOURCES MANAGEMENT

11.1 RESPONSIBILITIES

NMI 8831.1 assigns NASA facilities maintenance responsibilities, to include resources management.

11.2 FINANCIAL MANAGEMENT CATEGORIES

There are three basic financial management categories into which NASA financial management transactions are divided: Research Operations Support, Direct Programs and Program Support. An understanding of the difference between the three is fundamental to an understanding of NASA resources management. Each is described below.

11.2.1 RESEARCH OPERATIONS SUPPORT

Research Operations Support is funded primarily by the R&D and SFC&DC appropriations. It covers overhead functions and services provided to all Field Installation customers. It includes the general and administrative activities required to operate and maintain an installation regardless of the programs and projects carried out at the Field Installation. Research Operations support includes support services contracts, supplies, equipment, and other goods and services necessary to carry out the general and administrative functions of the Installations, including facilities maintenance common to all installation tenants and other space-occupying agencies. Although some facilities maintenance in direct support of specific programs and projects is funded by Program Support funds (described below) or other reimbursable funds, facilities maintenance is

considered to be Research Operations Support.

11.2.2 DIRECT PROGRAMS

Direct Programs consists of budget accounts established by NASA Headquarters with funds taken from the Research and Development (R&D) and Space Flight, Control, and Data Communications (SFCDC) appropriations. These are clearly programmatic in nature and are planned, budgeted, authorized and controlled as a specific program or project rather than a program support activity. Direct Programs activities include civil service personnel and travel, end-items purchases or services that are linked to a specific program, including facilities maintenance costs in support of direct programs.

11.2.3 PROGRAM SUPPORT

Program Support consists of budget accounts established by NASA Headquarters with funds taken from the Research and Development (R&D) and Space Flight, Control, and Data Communications (SFCDC) appropriations and provided to Field Installation Directors for Field Installation use in supporting specific programs and projects. The Program Support accounts support activities that contribute to the accomplishment of a program or project planned, budgeted, and authorized by a project manager and coordinated by a functional manager. These accounts support activities that include equipment procurement, maintenance, and minor contracts that are linked to specific programs and projects.

<u>Program Support Title</u>	<u>Institutional Associate Administrative Code Supported</u>
Program Mission Support (PMS)	Associate Administrator for Space Flight (Code M)
Engineering and Technical Base (ETB)	Associate Administrator for Space Flight (Code M)
Program Support (PS)	Associate Administrator for Aeronautics and Space Technology (Code R)
Multi-Program Support (MPS)	Associate Administrator for Space Science and Applications (Code S)

Table 11-1. Program Support Categories.

There are four accounts in the Program Support category. The accounts are basically the same, but are titled differently by each of the NASA Headquarters Institutional Associate Administrators they support. The account titles and codes they support are shown in Table 11-1. Note from Table 11-1 that Code M uses two Program Support categories, PMS and ETB.

11.3 FACILITIES MAINTENANCE SUPPORT APPROPRIATIONS

There are four appropriations that support facilities maintenance. They are listed in order of the contribution each makes to facilities maintenance, largest to smallest:

- Research and Development (R&D)
- Research and Program Management (R&PM)
- Space Flight, Control, and Data Communications (SFCDC)
- Construction of Facilities (CoF)

Each is described below. The appropriation definitions quoted are taken from annual appropriation's acts (Appendix C, reference 18).

The word "maintenance" has been underlined in three of the four definitions to emphasize that each of the three can be used for facilities maintenance.

11.3.1 RESEARCH AND DEVELOPMENT (R&D)

This is a Congressional appropriation "...[f]or necessary expenses, not otherwise provided for, including research, development, operations, services, minor construction, maintenance, repair, rehabilitation and modification of real and personal property; purchase, hire, maintenance, and operation of other than administrative aircraft, necessary for the conduct and support of aeronautical and space research and development activities of the National Aero-

nautics and Space Administration..." (underlining added).

This appropriation is used to fund facilities maintenance in direct support of R&D programs.

R&D is a multi-year (two year) appropriation.

11.3.2 RESEARCH AND PROGRAM MANAGEMENT (R&PM)

This is a Congressional appropriation "...[f]or necessary expenses of research in Government laboratories, management of programs and other activities of the National Aeronautics and Space Administration, not otherwise provided for, including uniforms or allowances therefore...awards, lease, hire, maintenance and operation of administrative aircraft; purchase...and hire of passenger motor vehicles; and maintenance and repair of real and personal property, and not in excess of \$200,000 per project for construction of new facilities and additions to existing facilities, repairs, and rehabilitation and modification of facilities..." (underlining added).

R&PM is a one-year appropriation, meaning that the funds must be obligated during the year of the appropriation.

11.3.3 SPACE FLIGHT, CONTROL, AND DATA COMMUNICATIONS (SFCDC)

This is a Congressional appropriation "...[f]or necessary expenses, not otherwise provided for, in support of space flight, spacecraft control and communications activities of the National Aeronautics and Space Administration, including operations,

production, services, minor construction, maintenance, repair, rehabilitation, and modification of real and personal property; tracking and data relay satellite services as authorized by law; purchase, hire, maintenance and operation of other than administrative aircraft..." (underlining added).

SFCDC funds used for maintenance are nearly always in direct support of the Space Shuttle Program (Code M) or for Deep Space Network (DSN), Tracking and Data Relay Satellite Systems (TDRSS) Space Network, and Spaceflight Tracking and Data Network (STDN) facilities in support of the Office of Space Operations (Code O).

SFCDC is a multi-year appropriation, meaning that the funds can be obligated over multiple years depending upon the language in the annual appropriations act.

11.3.4 CONSTRUCTION OF FACILITIES (CoF)

This is a Congressional appropriation "...[f]or construction, repair, rehabilitation, and modification of facilities, minor construction of new facilities and additions to existing facilities, and for facility planning and design not otherwise provided, for the National Aeronautics and Space Administration and for the acquisition or condemnation of real property, as authorized by law..."

With certain specific exceptions individual projects costing in excess of \$200,000 must be funded with CoF funds; however, CoF funds may be used also for projects costing less than \$200,000 if the original estimate was more than \$200,000.

CoF is a multi-year appropriation, depending upon the language in the annual appropriations act.

11.4 THE BUDGET PROCESS

In summary, the annual budget process consists of three basic stages:

- Formulation Stage
- Review and Enactment Stage
- Execution Stage

Each stage is described briefly below and is discussed in detail in the *NASA Budget Administration Manual* (NHB 7400.1) (Appendix C, reference 10). The budget cycle and timetable are shown in Figures 11-1 and 11-2, respectively. The cycle is depicted as a closed-loop system in Figure 11-3.

11.4.1 BUDGET FORMULATION STAGE

The primary offices and the functions performed by each office in the budget formulation stage are as follows:

11.4.1.1 Office of Management and Budget (OMB). OMB issues guidance and budget calls to Executive Branch departments and agencies, including NASA.

11.4.1.2 NASA Chief Financial Officer (CFO)/Comptroller. The NASA Chief Financial Officer (CFO)/Comptroller issues a budget call to the NASA program offices.

11.4.1.3 The Associate Administrators. The Associate Administrators are the NASA Headquarters officials responsible for budget preparation and submission. Primarily, they comprise the Institutional Associate Administrators, the Program Associate Administra-

tors, and their subordinate NASA Headquarters offices. They send guidance and budget call letters to the Field Installations. The facilities maintenance budget call process is described in Chapter 2.

11.4.1.4 Field Installations. The Field Installations prepare and submit budgets to the NASA Headquarters program offices.

11.4.1.5 The Associate Administrators. The Associate Administrators review Field Installation submittals and prepare and submit budget requests to the NASA Chief Financial Officer (CFO)/Comptroller.

11.4.1.6 NASA Chief Financial Officer (CFO)/Comptroller. The NASA Chief Financial Officer (CFO)/Comptroller prepares the NASA budget and submits it to the Administrator.

11.4.1.7 NASA Office of the Administrator. With the assistance of the Deputy Administrator, the NASA Chief Financial Officer (CFO)/Comptroller, and the several Assistant and Associate Administrators, the Office of the Administrator prepares the final NASA budget and submits it to the Administrator for approval and submission to OMB.

11.4.2 BUDGET REVIEW AND ENACTMENT STAGE

The primary offices and the functions performed by each office in the budget review and enactment stage are described in the following paragraphs.

11.4.2.1 Office of Management and Budget (OMB). OMB reviews agency budget requests and makes recommendations to the President. Agencies may appeal or "rec-

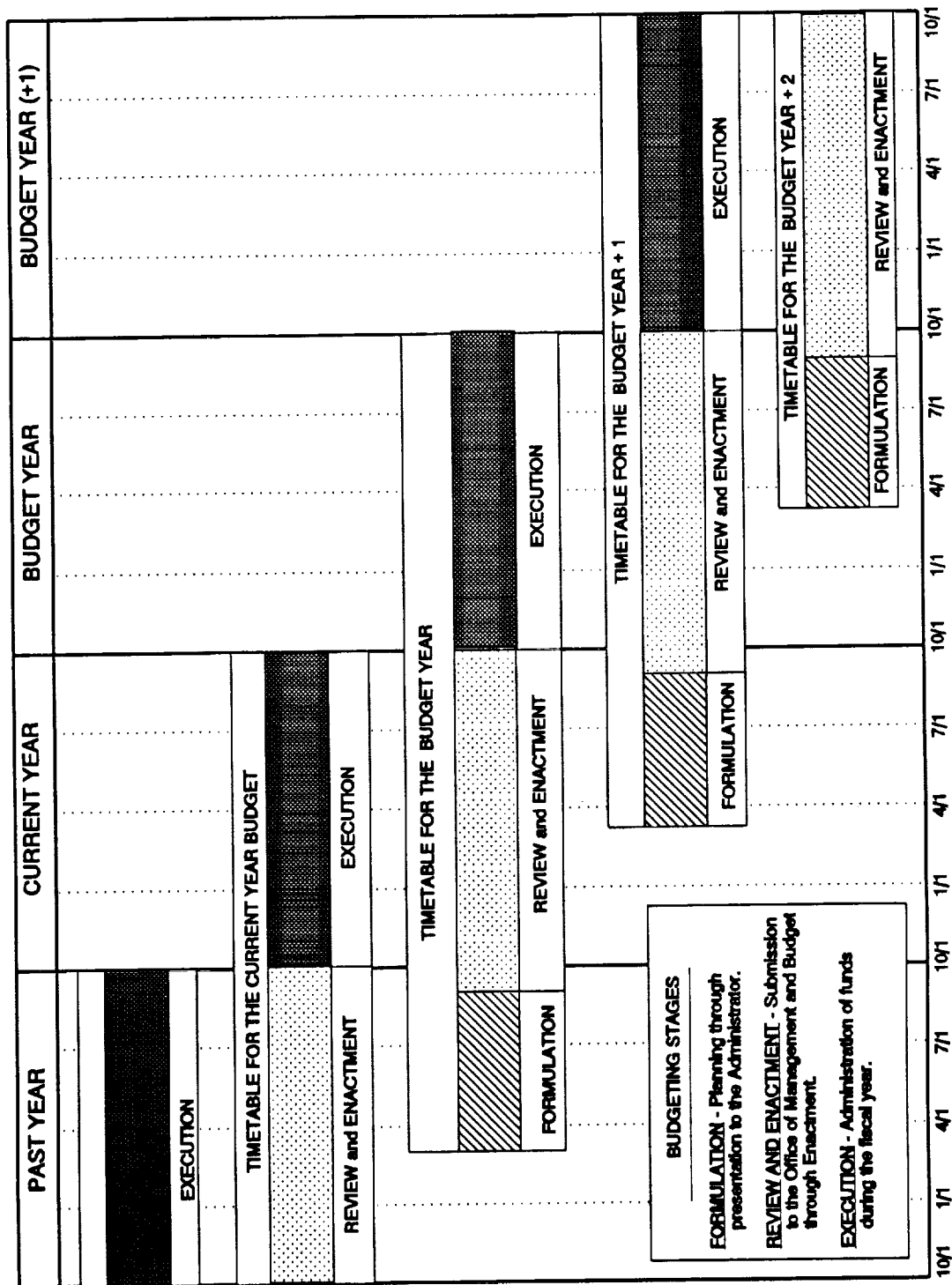


Figure 11-1. The Budget Cycle

FISCAL YEAR	MONTH	STAGE	MONTHS IN PROGRESS	ACTIONS
PAST YEAR	MARCH	FORMULATION 6 MONTHS	1	1. Develop and issue budget policies and assumptions to program offices. 2. Preview budget - Program office's submissions to the Administrator. 3. Preliminary budget submission to OMB. 4. Develop Budget Administration Manual guidance consistent with policies, etc. 5. Place "Call" for budget estimates. 6. Receive and review budget submissions.
	APRIL		2	
	MAY		3	
	JUNE		4	
	JULY		5	
	AUGUST		6	
CURRENT YEAR	SEPT	REVIEW AND ENACTMENT 13 MONTHS	7	1. President's budget - Initial submission to OMB. 2. OMB hearings. 3. Receipt of final mark-ups from OMB. 4. Prepare and submit final schedules for President's budget. 5. Printing of Federal Budget Document. 6. Prepare detail justification books for Congress. 7. Congressional Committee Hearings. 8. Review and approval of Program Operating Plans. 9. Enactment of Appropriations. 10. Receipt of Appropriation Warrants from Treasury. 11. Request for apportionment of funds to OMB. 12. Preparation and Issuance of Resource Authority Warrants & Allotments.
	OCT		8	
	NOV		9	
	DEC		10	
	JAN		11	
	FEB		12	
	MARCH		13	
	APRIL		14	
	MAY		15	
	JUNE		16	
	JULY		17	
	AUGUST		18	
	SEPT		19	
BUDGET YEAR	OCT	EXECUTION 12 MONTHS	20	1. Execution of Budget Program. 2. Review and approval of Program Operating Plans. 3. Mid-year adjustments of Resources Warrants & Allotments. 4. Semi-final adjustments of Resources Authority Warrants & Allotments. 5. End-of-year adjustments of Resources Authority Warrants & Allotments.
	NOV		21	
	DEC		22	
	JAN		23	
	FEB		24	
	MARCH		25	
	APRIL		26	
	MAY		27	
	JUNE		28	
	JULY		29	
	AUGUST		30	
	SEP		31	

Figure 11-2. The Budget Timetable

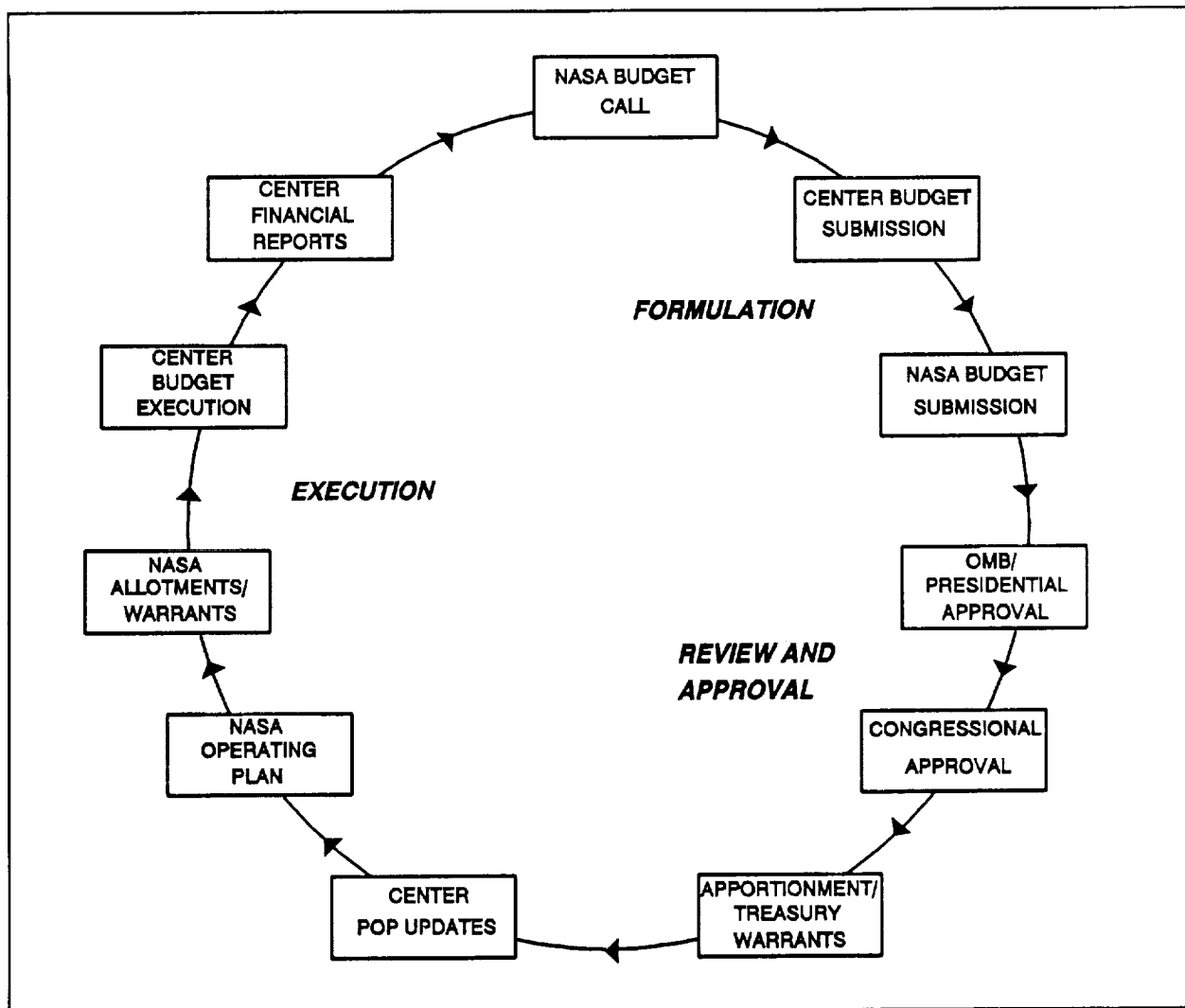


Figure 11-3. Budget Formulation, Review, Approval and Execution Process

lama" OMB recommendations to the President.

11.4.2.2 The President. The President considers the OMB recommendations and agency reclamas and makes the final budget decisions.

11.4.2.3 Office of Management and Budget. OMB notifies the Executive departments and agencies of the President's decisions and prepares and submits the President's budget to the Congress.

11.4.2.4 Congress. The NASA portion of the President's budget is reviewed by both the authorization and appropriations committees of both the House of Representatives and the Senate as follows:

- a. Authorization Committees. The authorization committees are the Committee on Science, Space, and Technology in the House and the Committee on Commerce, Science, and Transportation in the Senate. Both committees hold hearings at

which NASA testifies on what is contained in the President's budget. The committees then recommend an amount to the House and Senate. Upon approval by the House and Senate, an authorization bill is passed.

- b. Appropriations Committees. The appropriations committees for NASA are the Subcommittees on VA, HUD, and Independent Agencies of the Committee on Appropriations in both the House and the Senate. These committees hold hearings similar to those held by the authorization committees and make recommendations to the House and Senate. After approval by the House and Senate, an appropriations bill is passed.
- c. Conference Committees. Normally, the bills passed by the House and Senate for both the authorization and appropriations are different. When this occurs, each committee appoints members to a "Committee of Conference," whose function is to reconcile the two versions of the bill so that both the House and Senate can vote on a single bill. There is a conference between the House and Senate authorization committees and a conference between the House and Senate appropriations committees. Each "Conference Report" is voted by both houses and, upon passage, the final bills are submitted to the President for signature.

11.4.2.5. The President. Normally, after the President signs the bills, they become law.

11.4.3 BUDGET EXECUTION STAGE

11.4.3.1 General. Figure 11-4 illustrates the entire process of budget execution, from apportionment of the funds by OMB and provision of the warrants by the U.S. Treasury, to receipt of the funds by the Field Installations. Note that the NASA Chief Financial Officer (CFO)/Comptroller provides R&PM funds to the Associate Administrators (Codes D, M, O, R, S, and X), the Associate Administrator for Management Systems and Facilities (Code J) and the Inspector General (Code W). The Institutional Associate Administrators (Codes M, R, and S) then send R&PM funds to the Field Installations.

11.4.3.2 OMB/U.S. Treasury. Upon completion of Congressional action, NASA Headquarters requests apportionment of the funds by OMB. The U.S. Treasury issues appropriation warrants to NASA formally establishing in the Treasury the spending authority enacted in each appropriation. OMB then approves an apportionment of funds to NASA. See Steps 1 and 2 in Figure 11-4.

11.4.3.3 NASA Chief Financial Officer (CFO)/Comptroller. The Chief Financial Officer (CFO)/Comptroller requests that Program Directors and the Associate Administrator for Management update their IOP's/POP's to reflect the approved budget. The IOP's/POP's are described in Chapter 2. See Step 3 in Figure 11-4.

11.4.3.4 Program Directors and Associate Administrator for Management Systems and Facilities. These officials request that the Field Installations under their cognizance update their IOP's/POP's to include Con-

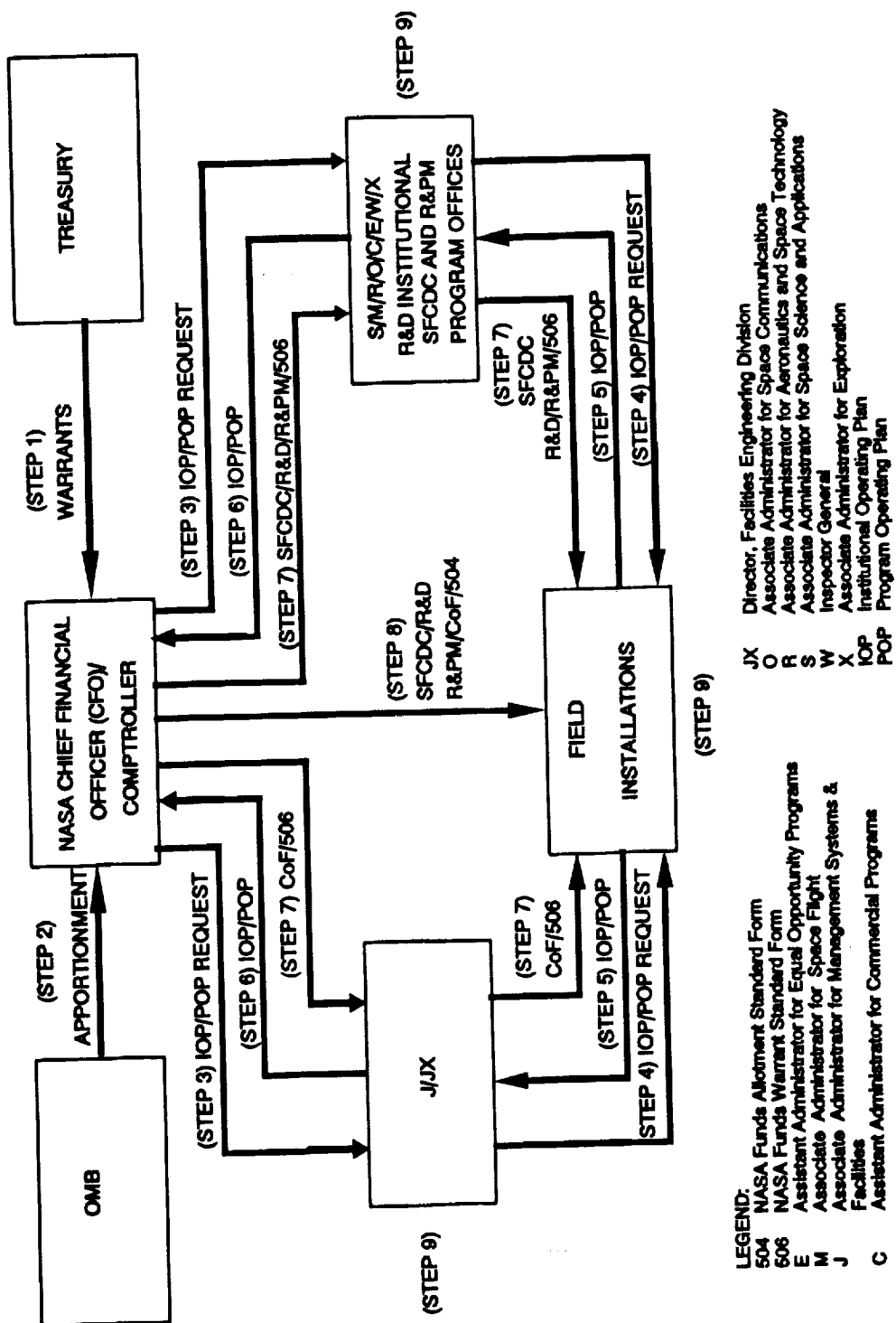


Figure 11-4. Approval of Funding Authority For Budget Execution

gressional authorization and appropriation action and NASA Headquarters guidance. See Step 4.

11.4.3.5 Field Installations. The Field Installations update their IOP's/POP's and submit them to the Program Directors and the Associate Administrator for Management. See Step 5.

11.4.3.6 Program Directors and Associate Administrator for Management. These officials update their IOP's/POP's with information received from the Field Installations and submit them to the NASA Chief Financial Officer (CFO)/Comptroller. See Step 6.

11.4.3.7 NASA Chief Financial Officer (CFO)/Comptroller. The Chief Financial Officer (CFO)/Comptroller updates the NASA operating plan using IOP's/POP's received from the Program Directors and the Associate Administrator for Management and submits the operating plan to the NASA Administrator for review and approval. After approval by the Administrator, the NASA Chief Financial Officer (CFO)/Comptroller issues NASA funds warrants (NASA Forms 506) to the Program Directors and the Associate Administrator for Management, who in turn issue the warrants to the Field Installations. See Step 7. At the same time, the NASA Chief Financial Officer (CFO)/Comptroller issues the fund allotments (NASA Forms 504) directly to the Field Installations. See Step 8. Normally, only one allotment is issued to the Field Installations for each of the facilities maintenance appropriations (SFCDC, R&D, R&P-M).

11.4.3.8 Program Directors, Associate Administrator for Management, and Field In-

stallations. These officials execute their programs, including facilities maintenance, by incurring commitments, obligations, and expenditures of the funds allotted to carry out approved programs. See Step 9.

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CHAPTER 12. FACILITIES MAINTENANCE MANAGEMENT AUTOMATION SYSTEMS

12.1 INTRODUCTION

This chapter provides amplification of concepts discussed in Chapter 6. The information is primarily for users new to maintenance management automation systems.

12.2 CONCEPTS

This paragraph outlines the major functions that a Computerized Maintenance Management System (CMMS) should support.

- Managing facilities and equipment.
- Providing utilities services.
- Assisting in formulating and administering contracts.
- Developing budgets and performing cost analyses.
- Providing management support.

12.2.1 MANAGE FACILITIES AND EQUIPMENT

This function contains the facilities maintenance processes and procedures and identifies and manages the facilities maintenance workload. This function also includes facilities planning and processes normally associated with Construction of Facilities (CoF) funding and must support those portions of CoF work that are a logical outgrowth of the facilities maintenance effort such as repair, modification, or rehabilitation.

12.2.2 PROVIDE UTILITIES SERVICES

Utilities services are essential to a Field Installation in that no operations would be

possible without the power, steam, water, and related services they provide. Utilities also represent a major cost of operations. Automation support is vital to energy conservation efforts as well as to effective system maintenance and management for optimal reliability and cost efficiency.

12.2.3 ASSIST IN FORMULATING AND ADMINISTERING CONTRACTS

Contracts provide the majority of Field Installation facilities support services. In many cases this extends to both recurring facilities maintenance efforts as well as one-time, specific facilities maintenance projects. Automation support for contract preparation and administration in support of the Contracting Officer is essential for a well managed facilities maintenance program.

12.2.4 DEVELOP BUDGETS AND PERFORM COST ANALYSES

Management is largely the process of allocating and directing resources to accomplish an organization's goals. The three functions listed above focus on the facilities maintenance work and work methods. The budget and cost analysis functions obtain and track resources. In an environment of competition for limited resources to perform an ever expanding workload, managers need sophisticated tools and techniques to account for resources, demonstrate efficient use of resources, and prepare persuasive requests for future resource allocations. Automation is essential to meet this end. Chapters 2 and 11 discuss resources management.

12.2.5 PROVIDE MANAGEMENT SUPPORT

Management support functions provide the routine internal organizational, administrative, and overhead processes. They include functions related to internal administrative support, office automation, document tracking, and personnel accounting performed within the facilities maintenance organization. While the internal management support functions do not interface directly with the facilities maintenance customers, shortcomings in this area directly impact customer support. Dealing with largely administrative matters, management support function productivity can improve through automation. Well established automation techniques are available for these areas. However, automation of management support and administrative functions is outside the scope of this manual.

12.3 CMMS ARCHITECTURE

This paragraph provides additional information on the CMMS system elements discussed in Chapter 6. They are:

- Databases
- Software
- Input/output

12.3.1 DATABASES

The following paragraphs describe the types of information typically found in CMMS databases. Field Installations should include additional information to meet specific local management needs. The groupings under each of the headings that follow represent one way to structure the data. Other groupings may meet specific local needs better.

12.3.1.1 Facility/Equipment Inventory. These data files contain a detailed inventory of all facilities and maintainable collateral equipment subject to the facilities maintenance management system (and could include other information if needed for planning, space management, or accounting purposes). For facilities, they include information such as identifier, size, cost, date acquired, category codes, uses, location, users, material condition codes, and other similar information. For equipment, they include nomenclature, manufacturer, part number, cost, serial number, date acquired, size, location, identifiers to major system or use, warranty, specific facilities maintenance requirements, life expectancy, and similar information. Tables 8-1 and 8-2 list representative data elements.

12.3.1.2 Facility/Equipment History. These data files contain summaries of the maintenance histories of the facilities and collateral equipment. They contain summaries of Preventive Maintenance (PM), Programmed Maintenance (PGM), Repairs, Trouble Calls, Rehabilitation, Modifications, Additions, Construction, and other work affecting the configuration or condition of the items. They include completed and canceled work orders. They also include the current material condition assessment of each item for use in developing an estimate of the backlog of deferred facilities maintenance.

12.3.1.3 Facility Graphic Documentation. Rapidly evolving technology in Computer Aided Design and Drafting (CADD), Geographic Information Systems (GIS), and similar systems such as Automated Mapping/Facility Management (AM/FM) permits the digitized storage of graphic data on individual facilities such as drawings, pho-

tos, and other pictorial information. GIS offers three-dimensional definition of a facility plus an associated database that together are a powerful facilities engineering tool. For example, a GIS for a street network could include data on underground utilities showing each utility (water, gas, electricity, sewage, storm drainage), parking, traffic volume, pavement condition, and landscaping each in a separate plane. The emerging GIS technology fully integrates graphics and text.

One GIS system is the Geographic Resources Analysis Support System (GRASS) and its three subsystems, GRID, IMAGERY, and MAP-DEV. GRID analyzes, overlays, and models maps and displays. IMAGERY displays, geo-references, compares, and classifies satellite and aerial photographic imagery. MAP-DEV enables digitizing and integrating landscape data generated from hard copy maps, digital elevation files, and other sources for analysis. This technology holds great promise for facilities maintenance applications.

Graphic documentation includes references to hard copy drawings, manufacturer's shop drawings, and drawings prepared at the Field Installation. Master plan drawings are in this group. Field Installations may wish to require the submission of all drawings, particularly those for facilities projects, in digitized form. Also, Field Installations should consider digitizing existing drawings for inclusion in the database.

12.3.1.4 Work Input Control/Scheduling/Trouble Calls. This data file contains information on work requested by customers, work generated internally, and work status as it proceeds from requirement identification to work completion or request disap-

proval. It includes information on requestor, cost estimate, funding, scheduling for execution, and execution status for each work order. This data provides the ability to track facilities projects, requests for facilities maintenance, Trouble Calls, and Service Requests.

12.3.1.5 Job Estimating. This data file may contain shop or flat rate guides, estimating tables, work performance (time and motion) standards such as engineered performance standards, labor and material rates, and local cost and time factors in computer-usable form. Sources include commercial services, government-developed standards (such as the Department of Defense (DOD)-developed Facilities Engineering Job Estimating (FEJE) software), and local experience. After the planners and estimators (P&Es) define the work elements comprising a job, they can use this data file to estimate task and work order crafts, materials, equipment, tools, time, and costs.

12.3.1.6 Preventive Maintenance. This data file contains information on facilities and equipment maintenance requirements and schedules. It contains data for equipment and facilities maintenance actions required, diagnostic aids, references to or excerpts from maintenance manuals and equipment drawings, schedules, frequency, materials, safety requirements, and related procedures. Linked with the inventory, the combined data files can be used to create a Preventive Maintenance schedule and work orders or PM action cards for use by mechanics.

12.3.1.7 Continuous Inspection. This data file contains information for the continuous inspection program. It includes facilities maintenance standards, inspection schedules,

inspection and test procedures, and Predictive Testing information. Linked with the inventory, it can be used to create the inspection orders and work sheets used by inspectors.

12.3.1.8 Space Management/Planning.

This data file typically contains user name and user data for each facility, space within the facility, or other asset managed. It may include other information for use in managing the space such as configuration, utilities services, finishes, furnishings, environment, communications, assigned function or task, and accounting information.

12.3.1.9 Tools/Material. Tools and material data files typically contain the inventory of centrally managed tools and material for use in support of facilities maintenance. The material data file aids in assigning material to work orders, supports the preparation of material requisitions, tracks the receipt of material on order, and documents related information. Also, these data files record accountability data for shop tools and equipment.

12.3.1.10 Contracts. This data file contains information on contracts supporting the broad spectrum of facilities maintenance management as required by the Contracting Officer, Contracting Officer's Technical Representative (COTR), and Quality Assurance Inspector (QAI). With other database files, it provides a picture of each contractor's past performance, current loading, and planned work. It could include information on specifications, Government furnished property, quality assurance, payment processing, delivery orders issued, schedules, and related matters. It should cover both contracts for specific facilities maintenance requirements and support services contracts.

12.3.1.11 Utilities. The utilities data file contains detailed information on utilities consumption, distribution, use, allocation to users, and cost. It could include modeling capability and linkage to utility control systems (UCS).

12.3.1.12 Environment. This data file contains environmental information, including permits, licenses, history of violations and citations, potential hazards, environmental compliance and related actions underway, and tracking of work or materials of special environmental interest. For example, it might include data on polychlorinated biphenyl (PCB) or asbestos hazards. This file can track disposal of hazardous waste and hazardous materials or the need for and processing of renewals of discharge permits.

12.3.1.13 Administration/Personnel/Financial. These data files contain information typically managed by other offices within the Field Installation to support facilities maintenance. The data often is not directly available to the CMMS or owned by the facilities maintenance organization. The information is of interest to the facilities maintenance organization in developing budgets, managing workload, and in making decisions. Examples include budget and financial information, personnel information such as recruiting, training, and skills inventories, office automation, and electronic mail. Often the information is available by accessing information systems operated by other Field Installation offices. Examples include:

- Agencywide Coding Structure (AWCS) Automated System for Financial Management (Appendix C, reference 11).
- Utilities billing information.

- Safety standards/accident reports.
- Mobile equipment inventory.
- Civilian personnel information (non-Privacy Act).

12.3.2 SOFTWARE

The term software refers to the program or programs a computer runs. It is the sequence of instructions, coded into a form the computer can understand, that tell the computer system what to do. It encompasses the definition of the data and its preparation, input, storage, retrieval, manipulation, report formats, and disposal.

12.3.2.1 User Interface. The user interface is the point of interaction between the user and the computer. It determines the actions required on the part of a user to obtain a given response from the computer. "User Friendly" is a common phrase describing an interface that is easy to learn and use, allowing a user to become productive quickly with minimal training. Both hardware and software combine to determine the degree of user friendliness, with software the dominant factor.

12.3.2.2 Off-the-shelf Software. Off-the-shelf (OTS) Software refers to products that are available commercially or from government sources, without the need for custom development or manufacture. OTS software is usually lower in cost than custom-developed software. OTS software enhancements often occur as the state of the art changes or the market demands new features and competitive forces come to bear. Users usually have an option to upgrade to newer versions of a software program at relatively low cost. However, because OTS software usually targets a broad market, it may not contain features required by a specific user.

12.3.3 INPUT/OUTPUT

Input/output refers to the processes of getting information into and out of the computer system. These terms can apply to the hardware, software, or human actions required.

12.3.3.1 Input. Input to the system includes the data, changes to the data, and user instructions communicated to the system directing it to take actions. Actions may include updating, processing, providing output, or taking some other action with respect to the data. Common devices used for input include keyboard, light pen, bar code reader, magnetic media such as floppy disk or tape, optical or compact disk (CD), digitizer, mouse, scanner, telephone link, connected sensor, network connection, and direct hook-up to other computers.

12.3.3.2 Output. Output from the system includes processed data and information on the state of the system, including prompts for user action. It may appear as reports, instructions, or a data stream. Common methods for output include the display monitor, printer, plotter, magnetic media such as floppy disk or tape, direct connection to another computer or network, and control signals to an auxiliary device or machine.

12.3.3.3 Remote Locations. Use of portable computers equipped with dial-in capability will enhance information gathering in the field and database maintenance. The use of dedicated data entry personnel is not necessary with modern systems and software, especially after initial system installation and initial data entry.

12.4 DECISION SUPPORT

Originally, automated facilities maintenance management systems provided benefits in simple task automation and accounting functions, enhancing the productivity of individuals by speeding processes. Automated systems providing management decision support are now common. Better software, including more powerful user-friendly report and query systems, gives a facilities maintenance manager the capability to sort, filter, and process the data, look for trends, areas requiring attention, or relationships that will aid in reaching decisions. He can conduct "what if" analyses to determine the impact of resource constraints or changing work priorities.

The information on inventory, condition assessment, and the backlog of deferred facilities maintenance can aid in the resource allocation process. The benefits apply at both NASA Headquarters and Field Installation levels as well as within the facilities maintenance organization. While the CMMS by itself will not make decisions, it can give managers the information they need to make better decisions. Paragraph 5.8 on Management Information Systems gives several suggestions for decision support reports. Each user should be free to develop the decision support aids he needs.

12.5 TRENDS

Systems are evolving rapidly, with new technology in hardware and software announced almost daily. Facilities maintenance is not normally on the leading edge of automation technology. In part, this is due to its primary involvement with existing facilities and equipment acquired without data automation support in mind. However,

advances in data automation techniques will gradually appear in facilities maintenance practices and procedures. Facilities maintenance managers should keep aware of trends in automation and automation applications that may provide future benefit.

12.5.1 EXPERT SYSTEMS

Expert systems have potential for application in facilities maintenance management. Simply stated, expert systems program an expert's knowledge into a computer so a non-expert user can enter information (in response to the computer's prompts) and the computer will then offer a solution, much as a live expert would. An example is the built-in test capability or maintenance diagnostics on some modern equipment.

12.5.2 MINIATURIZATION

Notebook-size computers now entering the market give a significant capability multiplier to the facilities maintenance worker. The worker can carry full access to the facilities maintenance database into the field. This includes drawings, diagnostic aids, parts lists, and manuals as well as access to expert systems support. The steady trend is for greater capability in smaller packages at lower cost.

12.5.3 INTERACTIVE DATABASES

Several initiatives are underway in the Government to expand the use of computers in the acquisition and logistics management processes. These will provide for on-line exchange of data, documentation, and deliverables between Government and private industry. For facilities maintenance this may eventually lead to full information on

facilities and collateral equipment, including drawings, manuals, parts lists, and diagnostic tools, being available for "dial-up" access. This can reduce the need for local databases on equipment. It may eventually provide a method of obtaining significant portions of the maintenance support information (MSI) discussed in paragraph 8.4.

Two initiatives worth noting are the DOD Computer Aided Acquisition and Logistics Support (CALS) System (Appendix C, references 23 and 24) and the Government-Industry Data Exchange Program (GIDEP) (Appendix C, reference 26). However, at this time neither program provides significant support to facilities maintenance matters.

1. The first part of the document is a letter from the President of the United States to the Congress, dated January 3, 1862. It is a very important document, as it contains the President's annual message to Congress. The letter is written in a very formal and dignified style, and it is one of the most important documents in the history of the United States. It is a very long letter, and it covers a wide range of topics, including the state of the Union, the economy, and the military. The President's message is a very important document, as it is the only one of its kind. It is a very long letter, and it covers a wide range of topics, including the state of the Union, the economy, and the military. The President's message is a very important document, as it is the only one of its kind. It is a very long letter, and it covers a wide range of topics, including the state of the Union, the economy, and the military.

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CHAPTER 13. WORK CONTROL SYSTEMS

13.1 INTRODUCTION

This chapter provides supplemental information and amplifying discussion to selected topics from Chapter 5.

13.2 COST ESTIMATING

Cost estimates serve several facilities maintenance management purposes. Their form and content depend on the ultimate use of the estimate.

13.2.1 SCOPING ESTIMATE

The scoping estimate is based on broad, unit-cost guidelines; it does not involve a detailed job plan or design. It is not appropriate as the basis for job performance evaluation or contract negotiations.

The scoping estimate is used in situations that do not call for details and high accuracy. Examples include estimates for developing budgets, estimates to aid in screening work packages to be included in the backlog of deferred facilities maintenance, or preliminary estimates for initial decision making on a request for work.

13.2.2 FINAL ESTIMATE

The final estimate is based on detailed job plans (as found in a facilities maintenance work order) or final contract plans and specifications. It is more reliable than a scoping estimate. Job performance evaluations, contract negotiations, or other exacting uses should be based on a final estimate because it reflects a detailed knowledge of the individual facilities maintenance actions

and the resources required. A final estimate can substitute for a scoping estimate, but it is more costly to produce.

13.2.3 ENGINEERED PERFORMANCE STANDARDS-BASED WORK ORDER ESTIMATE

The Engineered Performance Standards (EPS)-based work order estimate uses the specific maintenance tasks that must be combined to complete a job and the industrial-engineered time standards for these tasks to develop the estimate. Organized by craft and job phase, the EPS-based estimate presents the sequence of tasks for work accomplishment for each craft or shop. It assumes a specific method of work accomplishment and includes a detailed materials and tools list.

13.2.4 HISTORICAL ESTIMATE

The historical estimate uses prior performance of the maintenance tasks involved as its basis. It can have excellent validity, provided the new job tasks and methods are comparable to the historical database used in preparing the estimate.

There is minimal cost in developing a historical estimate. However, care must be taken to ensure that the historical data applies to the current job scope. Periodic validation of historical-based estimates against estimating standards is necessary to ensure that they are in line with accepted standards. This type estimate is especially valuable for repetitive or recurring tasks such as PM.

13.3 MANAGEMENT INFORMATION SYSTEMS

13.3.1 DETERMINATION OF REQUIREMENTS

Gathering, analyzing, and presenting information can be a costly process. Therefore, information collection, processing, or documentation should support a clear facilities management need. Paragraph 13.3.2 summarizes recommended facilities maintenance indicators and MIS-generated reports. The Field Installation should determine the specific information displayed in the reports, output formats, and distribution based on its needs.

13.3.2 ANALYSIS, REPORTS, AND RECORDS

The principal function of an MIS is to provide automated analysis and reports to support management needs. The analysis should examine both status and trends. Graphical presentation of numerical data and trends will aid managers in understanding the implications of the data. The following discussion of several types of analyses and reports may be important to a facilities maintenance manager.

The following descriptions are intentionally unstructured. Managers should tailor them to fit local data and needs. As discussed in Chapter 6, the MIS automation system also should provide ad-hoc query capability to permit one-time and customized reports and analysis.

- a. Status of Funds. This provides up-to-date status of funds by source, including amounts authorized, reserved, and obligated. It also in-

cludes a comparison of planned to actual expenditure rates.

- b. Status of Work. This report provides the status of all work submitted to the facilities maintenance organization. It shows a short title for the work, work generation date, who or which organizational element has action, and where possible, an estimated completion date. Variations of this report include arranging the information by customer, work classification, status (grouping work items with similar status into one report), or facility. It can take the form of a history of selected work items showing their progress through the facilities maintenance system.
- c. Status of Major Projects. This includes major undertakings such as Construction of Facilities (CoF) projects, major facilities maintenance projects, and projects of special Field Installation interest. The reports should reflect cost estimates, project milestones, and progress against those milestones.
- d. Annual Work Plan. The MIS should provide a display of annual resource requirements and status for major line items within each element that makes up the Annual Work Plan. This includes Preventive Maintenance (PM), Predictive Testing & Inspection (PT&I), Grounds Care, Programmed Maintenance (PGM), Repair, Trouble Calls, Replacement of Obsolete Items (ROI), Service Requests, Central Utilities Plant Operations & Maintenance, CoF, and related factors. It also should dis-

play current budget estimates for out-years and the backlog of deferred facilities maintenance.

- e. Work Input. Reports on work input would include statistics on work generation and the characteristics of that work. They may include information on Service Requests (arranged and tabulated by date of request, customer, special interest area, facility number, and craft) and work orders generated by the inspection program (PM inspections, PT&I, continuous inspections, operator inspections, specialized inspections), PM program, PGM program, Repair program, and Trouble Calls.
- f. Work Execution. Reports on work execution include information on shop schedules, planned work, job status, estimated vs. actual job performance, delayed or late jobs, and related performance indicators. They also include progress on the PM, PGM, PT&I, and condition assessment programs.
- g. Inventory. This includes displays of facilities and maintainable collateral equipment inventory statistics, use, user, age profiles, and similar data. Significant portions of this information can be used in space management and planning.
- h. Contracts. This section includes the status of contracts, contract execution, pending and executed modifications, and delivery orders. This should cover support service, one-time facilities maintenance, and CoF contracts.
- i. Materials. The status of materials inventory, orders, and jobs awaiting material are in this report.
- j. Utilities. This report contains information on production, consumption, costs, conservation measures and targets, and related factors such as weather profiles.
- k. Other. This category is a catch-all for those reports not directly tied to facilities maintenance but closely related or supporting facilities maintenance efforts. Examples include personnel status, correspondence tickler and tracking, and automation system statistics.

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CHAPTER 14. CONTRACT SUPPORT, ENVIRONMENTAL COMPLIANCE, AND SAFETY

14.1 CONTRACT SUPPORT

14.1.1 GENERAL

Much of the Field Installation facilities maintenance work is performed by contract, either by separate, specific, one-time CoF contracts, specific facilities maintenance contracts below the \$200,000 CoF threshold (using non-CoF funds), or support services contracts. In the case of the specific, one-time contracts, the facilities maintenance organization's responsibility is limited to initial facilities maintenance and repair requirements identification, perhaps preliminary scope definition or cost estimate preparation, and resumption of the maintenance responsibility after the contract is complete. For facilities maintenance support services contracts, the facilities maintenance organization has a greater responsibility. It should be involved throughout the procurement process in each of the following functions:

- Determining the need for the contract.
- Serving as a member of the procurement team.
- Drafting the schedule.
- Preparing the needs analysis.
- Writing the procurement plan.
- Writing the statement of work.
- Determining the contract type.
- Writing the quality assurance plan.
- Conducting quality assurance-surveillance during contract performance.

In fact, however, the extent of the facilities maintenance organization's involvement in the process depends upon the desires and capabilities of the Field Installation Procurement Officer and Procuring Contracting Officer (PCO). The facilities maintenance organization may be limited to providing the Contracting Officer's Technical Representative (COTR), in which case the only responsibilities the facilities maintenance organization may have are for contract surveillance, performance evaluation, and payment certification.

It should be noted that coordination with the cognizant procurement office is essential in obtaining quality services in a timely fashion. Additionally, emphasis should be placed on advance acquisition planning to ensure continuity of services.

14.1.2 RESPONSIBILITIES

14.1.2.1 NASA Headquarters. At NASA Headquarters, procurement is the responsibility of the Assistant Administrator for Procurement (Code H). Within Code H, the Acquisition Division (Code HW) is responsible for taking specific operational procurement actions in support of NASA headquarters.

14.1.2.2 Field Installations. At the Field Installations, procurement is the responsibility of the Procurement Office.

<u>Publication</u>	<u>Title</u>
48 CFR	Federal Acquisition Regulation (FAR)
NHB 5100.4	Federal Acquisition Regulation Supplement
NHB 8820.2	Facility Project Implementation Handbook

Table 14-1. NASA Procurement Publications

14.1.3 REFERENCES

Table 14-1 lists the basic NASA procurement publications.

14.2 ENVIRONMENTAL COMPLIANCE

14.2.1 GENERAL

Although environmental compliance is not the responsibility of the Field Installation facilities maintenance organization, virtually every facilities maintenance action has a potential impact on the environment. For this reason, facilities maintenance personnel must be knowledgeable about environmental requirements and become involved to the limit of their responsibilities.

14.2.2 RESPONSIBILITIES

14.2.2.1 NASA Headquarters. At NASA Headquarters, environmental compliance is the responsibility of the Director, Facilities Engineering Division (Code JX).

14.2.2.2 Field Installations. At Field Installations, environmental compliance is normally the responsibility of the Facilities Engineering Division.

14.2.3 REFERENCES

Table 14-2 lists the NASA publications that relate to environmental compliance.

14.3 SAFETY

14.3.1 GENERAL

Although the Field Installation facilities maintenance organization does not have the primary responsibility for safety, facilities maintenance personnel must be safety conscious and must participate in the Field Installation's safety program.

14.3.2 RESPONSIBILITIES

14.3.2.1 NASA Headquarters. The responsibility for safety policy and oversight are vested in the Safety Division (QS) within the Office of the Associate Administrator for Safety and Mission Quality (SMQ).

14.3.2.2 Field Installations. Final authority and responsibility for safety at a Field Installation rests with the Field Installation Director. The Field Installation Director will designate, in writing, an individual to serve as the Installation safety official who will be responsible for providing safety oversight of the Installation activities, for

<u>Publication</u>	<u>Title</u>
NMI 8800.13	Prevention, Abatement, and Control of Environmental Pollution
NHB 8800.11	Implementing the Provisions of the National Environmental Policy Act
NHB 7320.1	Facilities Engineering Handbook
NHB 8820.2	Facility Project Implementation Handbook

Table 14-2. NASA Environmental Compliance Publications

ensuring the safety of all Installation operations/programs, and implementing NASA safety policy. There are two NASA directives which define the types of maintenance that must be performed to ensure safety. These and other applicable safety directions are shown in Table 14-3.

14.3.3 REFERENCES

Table 14-3 lists the primary NASA Headquarters safety publications.

<u>Publication</u>	<u>Title</u>
NHB 1700.1 (V1)	Basic Safety Manual
NMI 1710.3	Safety Program for Pressure Vessels and Pressurized Systems
NHB 1700.6	Guide for Inservice Inspection of Ground-Based Pressure Vessels and Systems
NSS/GO 1740.9	NASA Safety Standard for Lifting Devices and Equipment
NMI 8710.2	NASA Safety and Health Programs
NHB 1700.1 (V9)	NASA Safety Manual - Fire Protection

Table 14-3. NASA Safety Publications

APPENDIX A

GLOSSARY

Addition - A physical increase to a real property facility that adds to the overall dimensions of the facility.

Allocation - (1) As used by the Office of Management and Budget and the Treasury Department, an amount set aside by an agency in a separate appropriation or fund account for the use of another agency in carrying out the purpose of an appropriation. This term applies to amounts set aside in transfer appropriation accounts and allocated working funds. (2) The authoritative assignment of a specific amount of funds or quantity of a resource to a specified agency or for a designated use, usually for a given period of time. (3) The portion of joint or indirect cost assigned to a specific objective such as a program, function, project, job, or service.

Allotment - An authorization, stated on a Form 504, to incur commitments, obligations, and outlays within a specific amount pursuant to an appropriation or other statutory authority. The allotment constitutes a legal limitation on the total amount of funds stated thereon, in accordance with procedures governing the administrative control of appropriations and funds, as implemented by NMI 9050.3.

Alterations - Work that changes the configuration of a facility (not maintenance or repairs) but that does not increase the value of the facility; for example, moving a door or electrical outlet.

Apportionment - The allocation of the appropriation made in writing by an official of the Office of Management and Budget of amounts available for obligation and outlay in an appropriation or fund account. OMB may specify that amounts apportioned may be available only for specified time periods, activities, functions, projects, objects, or combinations thereof. The amounts so apportioned limit the obligation to be incurred or, when so specified, outlays to be accrued.

Appropriation - Authority by an act of Congress to make payments out of the Treasury for specified purposes.

Annual Appropriation - An appropriation that is available for incurring obligations only during the one fiscal year specified in the appropriation Act.

Current Appropriation - An appropriation which is available for obligation during the current fiscal year.

Multiple-Year Appropriation - An appropriation which is available for incurring obligations for a definite period in excess of one fiscal year (e.g., CoF).

Glossary (continued)

Appropriation Year - In the case of an annual appropriation, that fiscal year in which obligations were authorized to be incurred.

Authorization - A separate Act which authorizes appropriations to be made.

Budget - A formal estimate of future revenues, obligations to be incurred, and outlays to be made during a definite period of time and, when determined to be appropriate, upon the basis of accrued expenditures and costs to be incurred.

Budget Authority - The right, provided by law, to enter into obligations that will result in immediate or future outlays involving Government funds, except that such term does not include authority to insure or guarantee the repayment of indebtedness incurred by another person or Government. The basic forms of budget authority are appropriations, contract authority, and borrowing authority. Budget authority may be classified by the period of availability (1-year, multiple-year, no-year), by the timing of Congressional action (current or permanent), or by the manner of determining the amount available (definite or indefinite).

Budget Cycle - The period of time that elapses from the initiation of the budget process to the completion thereof for a particular fiscal year.

Budget Execution - The processes involved at every level in budgetary administration subsequent to passage of an appropriation act. This includes preparation of operating budgets, apportionments, funding actions, review and approval of operating budgets, fund reporting, and report reviews.

Budget Formulation - The processes in preparation, review, and establishment of the annual budget presented to the Congress as a basis for appropriations.

Budget Guidelines - Both general and specific instructions furnished by a higher level of management as a basis for budget formulation and execution.

Budget Process - The process embracing all the stages through which the budget passes, namely, the formulation stage, the review and enactment stage, and the execution stage.

Budget Year - The fiscal year for which estimates are submitted, which is the period including Oct. 1 through the following Sept. 30 (see Fiscal Year).

Buildings - The classification "buildings" includes the cost of buildings, capital improvements of buildings, and fixed equipment which is normally required for the functional use of the building and becomes permanently attached to and made a part of the building and which cannot be removed without cutting into the walls, ceilings, or floors, such as plumbing, heating, and lighting equipment; elevators; central air-conditioning systems; and built-in safes and vaults.

Glossary (continued)

Also included is all equipment of any type built-in, affixed to, or installed in real property in such manner that the installation cost, including special foundations or unique utilities or services, or the facility restoration cost after removal, is substantial.

Call for Estimates - Instructions issued to prepare and submit budget estimates and estimated fund requirements for the budget year.

Central Utility Plant Operations & Maintenance - This category is unique in that it includes the cost of operations in addition to maintenance costs. It should be used only to capture the costs of operating and maintaining institutional central utility plants such as a central heating or steam plant, wastewater treatment plant, or a central air conditioning (chiller) plant. The concept is that operators are assigned full-time to operate the plant, but they perform maintenance between various operating tasks, making it almost impossible to segregate operational and maintenance costs; therefore, the costs of the full-time operators (and their materials) are shown here.

Collateral Equipment - Encompasses building-type equipment, built-in equipment, and large, substantially affixed equipment/property and is normally acquired and installed as part of a facility project as described below (also see Noncollateral Equipment):

Building-Type Equipment. A term used in connection with facility projects, and is that equipment normally required to make a facility useful and operable. It is built-in or affixed to the facility in such a manner that removal would impair the usefulness, safety or environment of the facility. Such equipment includes elevators; heating, ventilating and air conditioning systems; transformers; compressors; and other like items generally accepted as being an inherent part of a building or structure and essential to its utility. It also includes general building systems and subsystems such as electrical, plumbing, pneumatic, fire protection, and control and monitoring systems.

Built-In or Large, Substantially Affixed Equipment. A term used in connection with facility projects of any type other than building-type equipment which is to be built-in, affixed to, or installed in real property in such a manner that the installation cost, including special foundations or unique utilities service, or the facility restoration work required after its removal, is substantial.

Condition Assessment - Condition assessment is the inspection and documentation of the material condition of facilities and equipment, as measured against the applicable maintenance standard. It provides the basis for long-range maintenance planning as well as annual work plans and budgets.

Construction - The erection, installation, or assembly of: (1) a new or replacement facility, or (2) an addition in area, volume, or both to an existing facility.

Glossary (continued)

Construction Project - A facility project relating to the erection, installation, or assembly of a new facility, replacement facility, or an addition in area, volume, or both to an existing facility.

Continuous Inspection - A program of periodic, scheduled, inspections of facilities and equipment to determine their condition with respect to specified standards.

Contract Number - A Uniform Acquisition Instrument Identifier, pursuant to the NASA Federal Acquisition Supplement (NFS) Subpart 18-4.7100.

Contracting Officer - Any person who, by appointment in accordance with procedures prescribed by the Procurement Regulation (see Appendix C, reference 41, Part 1, Subpart 4), is currently a contracting officer with the authority to enter into and administer contracts and make determinations and findings with respect thereto, or with any part of such authority.

Contractor - The supplier of the end item and associated support items to the Government under the terms of a specific contract.

Contracts - All types of agreements and orders for the procurement of supplies or services. Includes awards and notices of award; contracts of a fixed-price, cost, cost-plus-a-fixed-fee, or incentive type; contracts providing for the issuance of job orders, task orders, or task letters thereunder; letter contracts; and purchase orders. It also includes supplemental agreements with respect to any of the foregoing.

Current Year - The fiscal year immediately preceding the budget year.

Design - This term is used to encompass both preliminary design and final design for facility projects. Design costs are normally funded under the Construction of Facilities appropriation. The criteria and standards applicable to the planning and design of facility projects are set out in NHB 7320.1. Design costs of facility projects proposed for funding under appropriations other than CoF are normally funded under the same appropriation from which the facility project is to be funded with such costs being identified separately from the facility project cost estimate.

Drawings - Graphic data, including drawings as defined in MIL-STD 100A and prepared in accordance with MIL-STD-1000, Category D; aperture cards in accordance with MIL-C-9877; and graphs or diagrams in accordance with industry standards and industry specifications, on which details are represented with sufficient information to define completely, directly, or by reference the end result for use in the selection, procurement, and manufacture of the item required.

Emergency Repair - The restoration of an existing facility or the components thereof when such facilities or components have been made inoperative by major breakdown, accident, or other circumstances, which could not be anticipated in normal operations, and the repair thereof is of

Glossary (continued)

such urgency that it cannot await programming and accomplishment in the normal budget cycle. In the process of emergency repair, the replacement of components or materials will be of the size or character currently required to meet firm demands or needs.

Energy Conservation Program within NASA - An amalgam of planning, design, construction, modification, and operational activities intended to reduce overall energy consumption 20 percent by the year 2000 with the year 1985 as base. Also considers use of alternate energy sources.

Energy Project - A facility project that provides improved use of all types of energy resources through conservation and/or increased efficiency. Savings in energy, staffing, and other areas must have a reasonably cost effective return on the project investment. Also, energy savings must represent a substantial part of the savings.

Estimated Cost - A calculated anticipated amount, as distinguished from an actual outlay, based upon related cost experience, prevailing wages and prices, or anticipated future conditions, usually for the purposes of contract negotiation, budgetary control, or reimbursement.

Facilities Contract - A contract type under which Government facilities and equipment are provided to a contractor by the Government for use in connection with the performance of separate, related procurement or support services contract(s) for supplies or services. The term includes facilities acquisition contracts, facilities use contracts, and consolidated facilities contracts.

Facilities Maintenance - The recurring day-to-day work required to preserve facilities (buildings, structures, grounds, utility systems, and collateral equipment) in such a condition that they may be used for their designated purpose over an intended service life. It includes the cost of labor, materials, and parts. Maintenance minimizes or corrects wear and tear and thereby forestalls major repairs (Facilities Maintenance does not include work on noncollateral equipment).

Facility - A term used to encompass land, buildings, other structures, and other real property improvements, including utilities and collateral equipment. The term does not include operating materials, supplies, special tooling, special test equipment, and non-capitalized equipment. (See FMM 9250-32 for criteria for capitalized equipment.) The term facility is used in connection with land, buildings (facilities having the basic function to enclose usable space), structures (facilities having the basic function of a research or operational activity), and other real property improvement.

Facility Improvement - That construction necessary to replace obsolete facilities or to expand a facility in order to improve the operating efficiency of an installation.

Glossary (continued)

Facility Project - The consolidation of applicable specific individual types of facility work, including related collateral equipment, which is required to fully reflect all of the needs, generally relating to one facility, which have been or may be generated by the same set of events or circumstances which are required to be accomplished at one time in order to provide for the planned initial operational use of the facility or a discrete portion thereof.

Field Installations - This term means the following NASA Installations and components thereof, listed by the NASA Headquarters Code having management responsibility:

Code M

- Johnson Space Center (JSC)
 - Downey
 - Palmdale
 - White Sands Test Facility (WSTF)
- Kennedy Space Center (KSC)
- Marshall Space Flight Center (MSFC)
 - Michoud Assembly Facility (MAF)
 - Santa Susana Field Laboratory
 - Slidell Computer Complex (SCC)
- Stennis Space Center (SSC)

Code O

- Deep Space Network
 - Canberra Deep Space Communications Complex
 - Goldstone Deep Space Communications Complex
 - Madrid Deep Space Communications Complex
- Spaceflight Tracking and Data Network
 - Bermuda
 - Dakar, Senegal
 - Merritt Island, Florida
 - Ponce de Leon, Florida
- Space Network Ground Terminals (White Sands)

Code R

- Ames Research Center (ARC)
 - Dryden Flight Research Facility (DFRF)
- Langley Research Center (LaRC)
- Lewis Research Center (LeRC)
 - Plum Brook Station (PBS)

Glossary (continued)

Code S

Goddard Space Flight Center (GSFC)
Wallops Flight Facility (WFF)
National Scientific Balloon Facility (NSBF)
Jet Propulsion Laboratory (JPL)
Edwards Test Station (ETS)
Table Mountain

Fiscal Year - In the Federal Government, it is the 12-month period from Oct. 1 of one calendar year through Sept. 30 of the following year.

Funding - The issuance of allotments (Form 504) which provides authority to incur commitments and obligations and make payments within appropriations made by the Congress, within the apportionment limitations established by the Office of Management and Budget, and within the approved resources authorization (Form 506).

Funding Availability - The amount of obligating authority provided by appropriations, contract authorizations, actual transfers to or from other appropriations, and anticipated reimbursements.

Government-Furnished Equipment (GFE) - Equipment in the possession of, or acquired directly by the Government and subsequently delivered or otherwise made available to a contractor. A more detailed definition may be found in FAR, Part 45.

Government-Furnished Property - Property owned by the Government and provided to a contractor for use in the performance of a contract. A more detailed definition may be found in FAR, Part 45.

Grounds Care - Grounds Care is the maintenance of lawns, shrubs, trees, sprinklers, right-of-ways and open fields, drainage ditches, other similar improvements to land, and pest control when performed outside of buildings. The maintenance tasks include mowing, spreading fertilizer, trimming hedges and shrubs, clearing ditches, snow removal, and related work. Included in this category is the cost of maintaining Grounds Care equipment such as mowers and tractors.

Improvements - An addition to land, buildings, other structures, and other attachments or annexations to land that are intended to remain so attached or annexed such as sidewalks, drives, tunnels, utilities and installed collateral equipment.

Institutional Operating Plan (IOP) - See Program Operating Plan (POP). When institutional costs are added to the POP, it becomes the IOP.

Glossary (continued)

Inventory - The facilities and equipment inventory is the foundation of an effective facilities maintenance management program. It is the baseline for what is to be maintained. The inventory should permit identifying maintainable items including those subject to preventive maintenance or operator maintenance.

Major Facility Work - Construction in excess of \$750,000. Repair, Rehabilitation and Modification in excess of \$1,000,000, and Land Acquisition and Emergency Repair approved under the provisions of Section 308(b) of the National Aeronautics and Space Act of 1958 (as amended) at any cost.

Minor Facility Work - Construction in excess of \$200,000 but not exceeding \$750,000. Repair, Rehabilitation and Modification in excess of \$200,000 but not exceeding \$1,000,000.

Modification - See Rehabilitation and Modification.

Noncollateral Equipment. All equipment other than collateral equipment. Such equipment, when acquired and used in a facility or a test apparatus, can be severed and removed after erection or installation without substantial loss of value or damage thereto or to the premises where installed. Noncollateral equipment imparts to the facility or test apparatus its particular character at the time, e.g., furniture in an office building, laboratory equipment in a laboratory, test equipment in a test stand, machine tools in a shop facility, computers in a computer facility, and it is not required to make the facility useful or operable as a structure or building. (See also Collateral Equipment.)

Obligation - An obligation is incurred when an order is placed, a contract awarded, a service received, or other similar transactions occur requiring disbursement of money. Obligations are the sum of undelivered orders, liabilities, and disbursements.

Operating Plan - A budget plan, when approved, that is the basis for funding and financial control of obligations, costs, and disbursements.

Past-Year - The fiscal year immediately preceding the current year.

Payback - The amortization period, in years, calculated by dividing the budget estimate by the total expected annual savings.

Predictive Testing and Inspection (PT&I) - Those testing and inspection activities for facility items that generally require more sophisticated means to identify maintenance requirements than those of preventive maintenance.

Preventive Maintenance (PM) - The planned, scheduled periodic inspection, adjustment, cleaning, lubrication, parts replacement, and minor (no larger than Trouble Call scope) repair

Glossary (continued)

of equipment and systems for which a specific operator is not assigned. Preventive Maintenance (PM) consists of many check point activities on items that, if disabled, would interfere with an essential Center operation, endanger life or property, or involve high cost or long lead time for replacement. PM is the cornerstone of any good maintenance program. A weak or nonexistent PM program results in much more emergency work and costly repairs.

Program Operating Plan (POP) - A time-phased projection of resource requirements in terms of planned rates of obligations (and in the case of major cost-reimbursement contracts, of planned rates of cost accruals), submitted periodically by field operating elements to officials-in-charge of Program Offices, and by these officials to the NASA Chief Financial Officer (CFO)/Comptroller. These estimates serve as a guide for resources authorization and funding and provide a baseline for measuring performance and for future budget planning. When institutional costs are added to the POP it becomes the Institutional Operating Plan (IOP). (See also Institutional Operating Plan.)

Program Year - A concept of accounting for funds, obligations, and outlays under a no-year appropriation by the identification of transactions in fiscal-year segments identified by the fiscal year in which the individual items were obligated.

Programmed Maintenance (PGM) - Programmed maintenance are those maintenance tasks whose cycle exceeds one year, such as painting a building every fifth year. (This category is different from PM in that if a planned cycle is missed the original planned work still remains to be accomplished, whereas in PM only the next planned cycle is accomplished instead of doing the work twice such as two lubrications, two adjustments, or two inspections).

Project - Within a program, an undertaking with a scheduled beginning and ending, which normally involves one of the following primary purposes: (1) the design, development, and demonstration of major advanced hardware items; (2) the design, construction, and operation of a new launch vehicle (and associated ground support) during its research and development phase; and (3) the construction and operation of one or more aeronautical or space vehicles and the necessary ground support in order to accomplish a scientific or technical objective.

Real Property - Any interest in land and anything permanently attached to it, including structures, fixtures, and their improvements.

Reclama - A formal appeal to higher authority for reconsideration of all or a part of a decision regardless of the subject matter involved; e.g., it includes a presentation by an activity, restating all or a part of previously budgeted fund requirements denied or reduced by a higher level authority, the Office of Management and Budget, or the Congress.

Rehabilitation and Modification - That facility work required to restore and enhance, alter, or adjust a facility or component thereof, including collateral equipment, to such a condition that

Glossary (continued)

it may be more effectively used for its presently designated purpose or so as to increase its functional capability. For simplification in facility project titles, work may be properly identified as rehabilitation provided the primary reason for accomplishment is that the basic restoration work must be done in any event. It is deemed prudent to accomplish any related enhancement, alteration or adjustment work at the same time. If the pressing requirement is for the alteration and adjustment work to achieve an increase in functional capability, then this may be simply classified as Modification even though restoration is also involved.

Reimbursement Source Code - A section of the Agencywide Coding Structure (AWCS) which provides information on the source of reimbursements.

Reimbursements - Amounts collected or to be collected for commodities, work, or services furnished or to be furnished to another appropriation or fund or to an individual, firm, or corporation, which by law may be credited to an appropriation or fund account. Amounts to be collected include accounts receivable, reimbursements earned but not billed, and amounts anticipated for the remainder of the year. They may also include interagency orders accepted and on hand, for which delivery has not been made, to the extent that the order is a valid obligation of the ordering agency and the collection will be credited to the appropriation being reported.

Repair - That facility work required to restore a facility or component thereof, including collateral equipment, to a condition substantially equivalent to its originally intended and designed capacity, efficiency or capability. It includes the substantially equivalent replacements of utility systems and collateral equipment necessitated by incipient or actual breakdown.

Replacement of Obsolete Items (ROI) - There are many components of a facility which should be programmed for replacement as a result of becoming obsolescent (no longer parts-supportable), or do not meet electrical or building codes or are unsafe but are still operational and would not be construed as a repair. Examples include:

- Electric switchgear, breakers, and motor starters.
- Elevators.
- Control systems.
- Boiler and central HVAC systems and controls.
- Fire detection systems.
- Cranes and hoists.
- A/C systems using CFC refrigerants.

Resources - The actual assets of a governmental unit such as cash, human resources, material, etc.

Glossary (continued)

Service Requests - Service requests are not maintenance items, but are so often performed by facilities maintenance organizations they become a part of the baseline. Service requests are requests for facilities related work which is new in nature, and as such should be funded by the requesting organization. They are requests initiated by anybody on the Center, are usually submitted on a form, often requires approval by someone before any action is taken, usually are planned and estimated, materials procured, and shop personnel discretely scheduled to accomplish the work.

Specifications - A document that stipulates methods, materials, performance, testing, limitations or other criteria that must be adhered to during the construction of a facility.

Standard - Maintenance standards are defined as the expected condition or degree of usefulness of a facility or equipment item. A maintenance standard may be stated as both a desired condition and a minimum acceptable condition beyond which the facility or equipment is deemed unsatisfactory.

Trouble Calls - Trouble Calls are generally called in by telephone by occupants of a facility (or facility managers or maintenance workers). This category is composed of two types of work.

Routine calls are minor facility problems that are too small to be estimated (usually less than about 20 man-hours or \$2,000), and are generally responded to by grouping Trouble Calls by craft and location.

Emergency calls, which normally start as a Trouble Call, requires immediate action to prevent loss of, or damage to Center property; to restore essential services that have been disrupted; or to eliminate hazards to personnel or equipment. Emergency work is usually a response type work effort, often initially worked by Trouble Call technicians. Due to its nature, emergency work is not restricted to a level of effort such as Trouble Calls.

Warrant - A document (NASA Form 506) granting authority to initiate, commit, obligate, and outlay funds, within funds available in the allotment, for conduct of approved projects and activities.

Work Control Center - The central organizational point for receipt, tracking, and management of work generated from all sources.

Work Generation - Work generation is the process of identifying and documenting maintenance deficiencies and requirements.

Work Order - The document directing the shops to perform certain items of maintenance work. It includes the specific maintenance task requirements (usually by craft), labor, material, and equipment estimates, coordinating instructions, and administrative and financial information.

APPENDIX B

ACRONYMS

A/C	Air Conditioning
A&E	Architect and Engineer
AM/FM	Automated Mapping/Facilities Management
AMMS	Automated Maintenance Management System
ARC	Ames Research Center
AWCS	Agency Wide Coding Structure
AWP	Annual Work Plan
BAM	Budget Administration Manual
BCI	Building Cost Index
BEPS	Building Energy Performance Standards
CADD	Computer Aided Design/Drafting
CALS	Computer-aided Acquisition and Logistic Support
CAM	Computer Aided Manufacturing
CCB	Construction Criteria Base
CD	Compact Disk
CFC	Chloro Fluoro Carbon
CMMS	Computerized Maintenance Management System
CoF	Construction of Facilities
COTR	Contracting Officer's Technical Representative
CRV	Current Replacement Value
CS	Civil Service
DFRF	Dryden Flight Research Facility
DLA	Defense Logistics Agency
DoD	Department of Defense
DoE	Department of Energy
DOS	Disk Operating System
DSN	Deep Space Network
ENR	Engineering News Record
EPA	Environmental Protection Agency
EPS	Engineered Performance Standards
ETB	Engineering and Technical Base
ETS	Edwards Test Station
FAR	Federal Acquisition Regulation
FEJE	Facilities Engineering Job Estimating
FMM	Financial Management Manual
FMS	Functional Management System
FY	Fiscal Year
GFE	Government Furnished Equipment
GFP	Government Furnished Property

Acronyms (continued)

GIDEP	Government - Industry Data Exchange Program
GIS	Geographic Information System
GPWS	Guide Performance Work Statement
GSA	General Services Administration
GSFC	Goddard Space Flight Center
HVAC	Heating, Ventilating, and Air Conditioning
IMS	Institutional Management System
IOP	Institutional Operating Plan
JPL	Jet Propulsion Laboratory
JSC	Johnson Space Center
KSC	Kennedy Space Center
LAN	Local Area Network
LaRC	Langley Research Center
LeRC	Lewis Research Center
LOE	Level of Effort
MADR	Maximum Allowable Defect Rate
MAF	Michoud Assembly Facility
MIS	Management Information System
MOU	Memorandum of Understanding
MPS	Multi-Program Support
MSC	Marshall Space Center
MSFC	Marshall Space Flight Center
MSI	Maintenance Support Information
NASA	National Aeronautics and Space Administration
NFARS	NASA Federal Acquisition Regulation Supplement
NMI	NASA Management Instruction
NSBF	National Scientific Balloon Facility
NSN	National Stock Number
O&M	Operations and Maintenance
OIG	Office of the Inspector General
OMB	Office of Management and Budget
OMES	Operations and Maintenance Energy Services
OSHA	Occupational Safety and Health Agency
OTS	Off-the-Shelf
P&E	Planner and Estimator
PBS	Plum Brook Station
PC	Personal Computer
PCB	Polychlorinated biphenyl
PGM	Programmed Maintenance
PM	Preventive Maintenance
PMI	Preventive Maintenance Inspection
PMS	Program Mission Support

Acronyms (continued)

POC	Point of Contact
POP	Program Operating Plan
PS	Program Support
PT&I	Predictive Testing and Inspection
PWS	Performance Work Statement
QA	Quality Assurance
QC	Quality Control
R&D	Research and Development
R&PM	Research and Program Management
RAM	Random Access Memory
RCM	Reliability-Centered Maintenance
ROI	Replacement of Obsolete Items
RPDB	Real Property Database
SCC	Slidell Computer Complex
SES	Shared Energy Savings
SFCDC	Space Flight, Control, and Data Communications
SOW	Statement of Work
SPCC	Spill Prevention Control and Countermeasure Plan
SR	Service Request
SSC	Stennis Space Center
STDN	Spaceflight Tracking and Data Network
TC	Trouble Call
UCS	Utility Control System
WCC	Work Control Center
WFF	Wallops Flight Facility
WIC	Work Input Control
WSTF	White Sands Test Facility

APPENDIX C

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APPENDIX D

SAMPLE MAINTENANCE MANAGEMENT FORMS AND DOCUMENTS

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APPENDIX D

SAMPLE MAINTENANCE MANAGEMENT FORMS AND DOCUMENTS

This appendix recommends sample forms for use in facilities maintenance management. The information in the forms should be part of a computerized maintenance management system (CMMS) database, and the forms themselves should be tailored to meet the needs of the users, the capabilities of the CMMS, and the other automation systems used. (The sample forms also should prove useful when comparing reports and formats during the evaluation of candidate CMMS.)

1. TROUBLE CALL TICKET

1.1 SAMPLE TROUBLE CALL TICKET

Figure D-1 is a sample Trouble Call ticket. It is used with Trouble Calls, may be used as an alternative to a standard work order for small jobs (typically involving 20 man-hours or less effort), and is usually not planned or estimated. It contains data fields considered essential for effectively managing Trouble calls and small jobs. Usually, it is printed on half-size sheets (often card stock) for use by the mechanic in the field. A printer may be located in the shops, remote from the work reception center to speed Trouble Call ticket delivery.

1.2 DATA ELEMENTS

The following data elements are recommended for the Trouble Call ticket system. The elements provide the information that the craftsman needs to perform the work and that management needs to analyze the work. All listed information need not be recorded if it is available in the CMMS or can be obtained from other data elements. For example, the FMS code need not be recorded if it can be obtained from the accounting data.

<u>Data fields:</u>	<u>Definition:</u>
1. Date:	The date the work was received by the work reception desk.
2. Time:	The time the work was received by the work reception desk.
3. Work Order Number:	The unique identifying number assigned to the Trouble Call ticket. On the example, it is shown in bar code as well as in numerals. (The use of bar codes can speed data entry and reduce data entry errors.)
4. Location:	The facility number and any other pertinent data regarding the location or work site of the requested work.
5. Priority:	The work priority rating.
6. POC:	Point of Contact, the name of the person requesting the work.
7. Phone:	The telephone phone number of the POC.


TROUBLE CALL TICKET		
 (3) 012345	Date: (1)	Time: (2)
	Location: (4)	
	Priority: (5)	
POC: (6)		Phone: (7)
Title: (8)		
Work: (9)		
Comments: (10)		
Material Used: (11)		
Shop: (12)	Shop: (13)	Shop: (14)
Hrs: (15)	Hrs: (16)	Hrs: (17)
Mech: (18)	Mech: (19)	Mech: (20)
Acct: (21)		
Class: (22)		Type: (23)
SI: (24)	Rcvd By: (25)	
Checked By: (26)		D/C: (27)

Figure D-1. Sample Form: Trouble Call Ticket

- 8. Title: A short description of the work. This should contain descriptive key words that can be used for database searches for similar work at a later date.
- 9. Work: A detailed statement of the work.
- 10. Comments: A space for the shops to record comments on the work performed.
- 11. Material Used: The material used for the Trouble Call ticket if beyond that carried as bench stock or in preexpended bins.
- 12. Shop: The craft shop performing the work. (The form permits entering up to three shops.)
- 13. Hrs: Hours, the amount of labor used to complete the Trouble Call ticket by each shop involved.
- 14. Mech: Mechanic, the initials (or other identifier) of the mechanic performing the work.
- 15. Acct: Accounting, the accounting data or charge number for financial accounting.
- 16. Class: Class, a locally definable descriptor for the work that can be used for analysis of Trouble Call tickets.
- 17. Type: The type of work, defined in paragraph 5.6.3.
- 18. SI: Special Interest, the indicator defined in paragraph 5.6.4.
- 19. Rcvd By: Received By, the person receiving the request for work.
- 20. Checked By: The person checking the completed work, if any (usually the supervisor).
- 21. D/C: Date Completed, date work completed (could include time also).

1.3 INSTRUCTIONS FOR USE

The Trouble Call ticket should be automated as part of the CMMS. Initial data entry can then be accomplished at a computer terminal by the work reception clerk as the work is received. In many cases requests will be received by telephone; however, they may be received by electronic mail where it is implemented. A Trouble Call ticket may be the means of issuing facilities maintenance work requested by other means, such as a request for facilities maintenance services (see paragraph 2), or as the result of an inspection, when the scope of work is small. The following discusses use of the form:

- a. The work order number is normally assigned by the CMMS; however, this can be accomplished manually. If it is assigned manually, it should be checked for duplications. The use of a bar code can speed subsequent processing and closing the Trouble Call ticket while reducing data entry errors. (Most CMMS support printing of bar codes.)
- b. The work reception clerk enters the Date, Time, Location, Priority, POC, Phone, Title, and Work data. Normally, this information is obtained during the initial telephone request.

The clerk must use the Field Installation's priority system when assigning the priority. The Work data entry may take the form of a description of the problem or the desired end result; for example, "Door closer is broken" or "Fix leaking sink." The Work data entry also can include special coordination instructions or specific due dates. It is essential that the POC and Phone data entries be correct to permit the shops to obtain additional information, if required. Based on the foregoing information, the work reception clerk determines and enters the Scope, Type, SI (Special Interest), and Acct (accounting data). The clerk completes the form by entering his/her name or other identifier in the Rcvd By block. (Bar coding can expedite completion of the ticket by using a dictionary of standard terms, phrases, and other data available to the work reception clerk. The clerk can scan a bar code dictionary entry in lieu of typing a data field. This offers the dual advantages of reducing keyboard errors and using standard vocabulary for the data element.) Once this data is entered, the Trouble Call ticket is sent to the shops.

- c. The shop supervisor reviews the Trouble Call ticket and assigns it to a mechanic for accomplishment, in accordance with its priority. Routine work is normally grouped by location and craft to minimize time lost in travel. In some cases a job may require specialized skills not found in the shop that normally performs Trouble Call tickets, in which case it is assigned to another shop for completion; for example, machining a special fitting.
- d. The mechanic performing the work enters the work performed in the Comments area and the Material Used if material beyond that carried as bench stock or in preexpended bins is required. Alternatively, the Materials Used information may be obtained as part of a materials management module in the CMMS when the material is issued to the mechanic. Unusual conditions encountered are noted in the Comments block as well. The mechanic initials the form upon completion.
- e. The shop supervisor enters the identification and the labor hours used on the Trouble Call ticket. The shop supervisor checks the completed form to ensure that all entries are made and returns it to the work control center to be closed. If the supervisor or other official inspects the completed work, he indicates this by initialing the Checked By block.
- f. When the completed form is returned to the work control center, it is closed by entering the completion data in the CMMS. This will normally include labor and material expenditures, completion date, and applicable comments on work performed. The information becomes part of the maintenance history file. A hard copy of the Trouble Call ticket need not be retained if the data is stored in the CMMS and backed-up. If it is determined by the mechanic or supervisor that follow-up action is required, the work reception clerk enters the required action into the work control system. This may take the form of another Trouble Call ticket or a request for facilities maintenance services (see paragraph 2).

2. REQUEST FOR FACILITIES MAINTENANCE SERVICES

2.1 SAMPLE FORM: REQUEST FOR FACILITIES MAINTENANCE SERVICES

Figure D-2 is a sample form used by customers to document Service Requests or to request other facilities maintenance services. The primary purpose for this form is to document requests for work. The key factors are ensuring that sufficient data is obtained to identify, describe, and manage the work; that the work is properly authorized; that the work is properly tracked; and that accountability is maintained. The work may be accomplished as a Trouble Call ticket, a work order, or by separate contract, depending on its urgency, scope, and cost. The determination on how the work is accomplished is made as part of the facilities maintenance management process.

2.2 DATA ELEMENTS

<u>Data Fields:</u>	<u>Definition:</u>
1. Originator:	The name (or other identifier) of the requesting organization/customer.
2. Date:	The date the request is submitted.
3. POC:	Point of Contact, the name of the person to be contacted regarding the request.
4. Phone:	The telephone number for the POC.
5. Cust. No.:	Customer Number, an identification number assigned by the submitting organization. (This is optional, but it gives the originator the ability to assign his own identification or tracking number.)
6. Location:	The facility number and any other pertinent data regarding the location where the work is to be done.
7. Priority:	The work priority rating.
8. RCD:	Requested Completion Date, the completion date requested for the services.
9. Estimate Only:	An indicator that the originator wants a cost estimate for the work requested rather than immediate performance of the work.
10. Requestor Signature:	The signature of an individual authorized to submit requests from the requesting organization. (Other validation systems may be used, such as an authorization number if received by electronic mail.)
11. Requested Work:	A description of the requested work and a justification for the request if it is for other than maintenance.
12. Special Instructions:	Any special permits, coordination, outages, or other requirements the originator is aware of that apply to this work.
13. WICN:	Work Input Control Number, a unique identifier assigned by the facilities maintenance organization to identify the request for

REQUEST FOR FACILITIES MAINTENANCE SERVICES			
Originator: (1)		Date: (2)	
POC: (3)		Phone: (4)	Cust. No.: (5)
Location: (6)		Priority: (7)	
RCD: (8)	Estimate Only: (9) Y N	Requestor Signature: (10)	
Requested Work: (11)			
Special Instructions: (12)			

APPROVAL/ACTION/ESTIMATE			
WICN: (13)	Date Rcvd: (14)	W.O. # (15)	ESTIMATED COSTS-> Labor: (16)
Approval Status: (21) APPROVED: APPROVED (Subject to customer funding): DISAPPROVED:			Material: (17)
Comments: (22)			Equipment: (18)
			Other: (19)
			Total Est: (20)

REQUESTOR FUNDING DATA	
Fund Citation/Accounting Data: (23)	
Authorizing Signature: (24)	Date: (25)

Figure D-2. Sample Form: Request for Facilities Maintenance Services

- subsequent tracking by the facilities maintenance organization. The date the request is received by the facilities maintenance organization work reception desk.
14. Date Rcvd: Work Order number, the identifying number of the work order that the requested work is being accomplished under, if applicable.
15. W.O. #: Estimated labor cost for the work.
16. Labor: Estimated material cost for the work.
17. Material: Estimated equipment cost for the work.
18. Equipment: Estimated other costs for the work. (This could include items such as one-time contracts for portions of the work.)
19. Other: Total estimated cost.
20. Total Est.: An indicator to document that fact that: (a) the work is approved and will be performed by the facilities maintenance organization using the funds cited in block 23, (b) is approved subject to funding by the originator, or (c) is disapproved.
21. Approval Status: Additional information such as the reason for disapproval or a note regarding sketches or attachments to a returned estimate.
22. Comments: A fund citation or accounting data to cover the work.
23. Fund Citation: Signature by competent authority granting approval to charge the funds in the Fund Citation data field for the work.
24. Authorizing Signature: The date the Authorizing Signature is affixed.
25. Date: This information is not shown on the sample printed form, but should be contained in the CMMS database. It is a series of status tracking data fields used by the facilities maintenance organization. The status data includes the date and current processing status of the request as well as who has the request for action and what actions have been completed.
26. Internal Status:

2.3 INSTRUCTIONS FOR USE

The Request for Facilities Maintenance Services should be automated as part of the CMMS; however, because it originates with a customer, entry into the CMMS may not take place until after it is submitted by the originator and received by the work control center. Where electronic mail is available or customers have network access to the CMMS, it may be possible to automate the submission and initial data entry. The form is used as follows:

- a. The originator provides the required information for data fields 1 through 12, 23, 24, and 25. The remaining fields are the responsibility of the facilities maintenance organization. Normally, fields 1-12 are filled in at the time of the initial submission. The Estimate Only "Y" block is selected if the originator is requesting only a cost estimate.

- b. When the facilities maintenance work reception desk in the work control center (WCC) receives the request, the work reception clerk enters the date received and assigns a work input control number for tracking purposes.
- c. The WCC (typically the work reception clerk) screens the request to determine what action is required. If the request is for work properly accomplished as a Trouble Call ticket, the WCC prepares a Trouble Call ticket and notes this in the Work Order block (15) and the Comments block (22). The WCC notifies the originator by completing the Approval Status (21) and returning a copy to the originator.
- d. If the request is only for an estimate, the WCC forwards it to the estimators. When the P&Es complete the estimate, they fill in the Labor, Material, Equipment, Other, and Total blocks (16 - 20) and return it to the WCC. The WCC notifies the originator by returning a copy of the request with the estimate data. The returned package may include the detailed estimate and job plan prepared by the P&E, a request for funds, and a tentative or conditional scheduling window for the work.
- e. If the request is for the performance of work that requires planning and estimating and it has received preliminary approval, the WCC forwards it to the P&E's for detailed job planning and estimating. When the P&E's complete the job package (including a work order), they return it to the WCC. The WCC then forwards it to the proper official for final review and approval.
- f. If approved, the WCC completes the Work Order #, Approval Status, and Comments blocks (15, 21, and 22) and notifies the originator. If the originator should fund the job, it proceeds as request for estimate as discussed in paragraph 2.3d. The reasons for originator funding should be stated in the comments. If the originator provided funding data for the request, it is entered into the shop load plan for execution when final approval is given.
- g. If the request is disapproved, the WCC enters this in the Approval Status and Comments blocks (21 and 22) and notifies the originator. Because disapprovals can cause customer discontent, the WCC should ensure review by an appropriate manager in the facilities maintenance organization before notifying the originator.
- h. The Internal Status data elements (item 26, not shown on the form) are used to track the status and progress of the request. As the request moves through the facilities maintenance management process and facilities maintenance organization, the WCC enters the date, status, and responsible action party. This provides a history of the request.

3. FACILITIES MAINTENANCE WORK ORDER

3.1 SAMPLE FORM: FACILITIES MAINTENANCE WORK ORDER

Figure D-3 is a sample facilities maintenance work order form. The form is generic, but it illustrates the information recommended for a work order. Figure D-4 is a sample continuation sheet that supports the sample facilities maintenance work order form. Figure D-5 is a sample facilities maintenance work order material/equipment requirements form that can be used to document the materials and equipment required for the work order. The actual forms used should be tailored to the Field Installation's needs and the CMMS used.

3.2 DATA ELEMENTS

- | | |
|----------------------|---|
| 1. W. O. #: | Work Order number, this number is used to track the work order and related actions throughout its life. On the sample it is shown both as a bar code and as numerals. One work order may be issued to cover more than one work request. |
| 2. WICN: | Work Input Control Number, a unique number assigned by the facilities maintenance organization to identify a request for facilities maintenance services for subsequent tracking of the request. One work request may result in more than one work order. |
| 3. Priority: | The work priority rating. This may not be the same as the priority requested by the originator on the Request for Facilities Maintenance Services form. |
| 4. RSD: | Required Start Date, the date work can or must start as applicable. This may be determined by the availability of the facility or the time required to meet the completion date. |
| 5. RCD: | Required Completion Date, the required completion date for the work order. Where possible, this should be the same date as on the Request for Facilities Maintenance Services form. |
| 6. Type: | The type of work as defined in paragraph 5.6.3 or locally. |
| 7. SI: | Special interest, an indicator as defined in paragraph 5.6.4 or locally. |
| 8. Class: | Class, a locally definable descriptor for the work that can be used for analysis of work. |
| 9. Facility #: | The facility number as recorded in property records. |
| 10. UDF: | User definable field, a locally definable descriptor for the work that can be used for analysis of work. |
| 11. Accounting Data: | This is the applicable accounting data for the work order. |
| 12. UDF: | User definable field, a locally definable descriptor for the work that can be used for analysis of work. |
| 13. POC: | Point of Contact, the name of the customer organization's POC responsible for this request. This is needed by the shops for |


FACILITIES MAINTENANCE WORK ORDER					W.O. #: (1)	
WICN: (2)	Priority: (3)	RSD: (4)	RCD: (5)	 012345		
Type: (6)	SI: (7)	Class: (8)	Facility #: (9)	UDF: (10)		
Accounting Data: (11)				UDF: (12)		
POC: (13)			Phone: (14)	Equip. #: (15)		
Title: (16)						
General Description: (17)						
WORK ORDER ESTIMATE						
WORK BREAKDOWN				ESTIMATE SUMMARY (25)		
Line #	Shop	WORK TASKS	HRS	Shop	HRS	Labor
(18)	(19)	(20)	(21)			
Special Instructions: (22)				Subtotal:		
				Contingency:		
Continuation: (23)				Overhead, etc.:		
Sketches: (24)				Total Estimate:		
Approved: (26)			Date: (27)	Estimate Basis: (28)	Completed: (29)	

Figure D-3. Sample Form: Facilities Maintenance Work Order

- | | |
|---------------------------|---|
| | coordination purposes. |
| 14. Phone: | The telephone number for the POC. |
| 15. Equipment #: | The equipment inventory number, as recorded in property records. This field applies only when the work is to be done on an equipment item. It can be the principal equipment item if the work order covers multiple equipment items. |
| 16. Title: | Short descriptive title of the work order. |
| 17. General Description: | A narrative description of the scope and intent of the work order. |
| 18. Line #: | Sequential task numbers. |
| 19. Shop: | Shop, the shop or craft group planned to perform the task. |
| 20. Work Tasks: | A statement of each task required to complete the work order. |
| 21. HRS: | Hours, the amount of labor required to complete the task. Normally, this is based on an estimating standard. |
| 22. Special Instructions: | Any special instructions or directions not covered in the listed work tasks. |
| 23. Continuation: | Statement that material and continuation sheets are provided where all tasks and material/equipment requirements are not entered on this form. Continuation sheets are forms that contain the work order number and additional work breakdown lines (see Figure D-4). |
| 24. Sketches: | Reference to drawings or sketches. Ideally, drawings would be from a graphics information system or CADD system that is integrated with the CMMS. The drawings, sketches, and other graphics would be prepared, printed, and attached to the work order. |
| 25. Estimate Summary: | This multi-field section is a summary of the work order estimate by shop, listing the estimated hours, labor cost, material cost, and total costs, together with any overall reservations for contingencies, overhead, or surcharges, and the total estimate. |
| 26. Approved: | Signature authorizing release and execution of the work order. |
| 27. Date: | Date the work order is approved for execution. |
| 28. Estimate Basis: | A field to identify the basis of the cost estimate or the estimating standard used. |
| 29. Completed: | The date the work order is completed. |

The work order material/equipment requirements form (Figure D-5) includes the following additional data elements:

- | | |
|--------------|--|
| 30. Item #: | Sequential number of item on the requirements list. |
| 31. Stock #: | The stock number of the required item. This may be a local stock number, a National Stock Number (NSN), a manufacturer's part number, or other identifier. If other than a local stock |

- number or NSN, supporting information (e.g., the identity of the manufacturer) should be given with the description.
32. Description: Nomenclature, supplier, etc. of the required item or equipment.
33. UM: Unit of measure; e.g., lf., ea., gal., hrs.
34. Qty: Quantity required.
35. Unit Cost: Unit cost of the item.
36. Total: Total cost of the specified quantity of the item.
37. Avail: Availability of the material. Enter the material delivery due date or a symbol to show that the material is in stock and ready for issue to the shops.

3.3 INSTRUCTIONS FOR USE

The facilities maintenance work order form provides the work authorization and direction to the shops. It also documents the work phases and cost estimate. Except for the accounting data and approval signatures, the work order form, continuation form, and material/equipment requirements forms usually are prepared by the P&E's. Normally, the accounting data is assigned as part of the final approval process. The use of a bar code on the work order form, the work order continuation form, and the material/equipment requirements form speeds subsequent processing, material issue, and closing of the work order while reducing data entry errors. (Most CMMS support printing of bar codes.)

After the work order has final approval, it is distributed to the shops, the material manager, the customer (in the case of customer-requested work), and others as determined by Field Installation policy. Distribution may be accomplished electronically if E-Mail is available, or if the CMMS work order database is shared on a network. The form shown contains all information concerning the work order and goes beyond the information requirements of many users of the form. For example, the material manager may not need the detailed task breakdown. With electronic distribution it is possible for users to receive only necessary extracts of the data.

When the work order is completed, it is closed and the information is added to the facility history files. The completion date is recorded and reported to the work control center.

4. SHOP LOAD PLAN

4.1 SAMPLE FORM: SHOP LOAD PLAN

Figure D-6 (see fold-out pages at the end of this appendix) is a sample shop load plan form. The CMMS used by the Field Installation should support computer-aided scheduling, including interactive manpower and other resource scheduling and schedule balancing. The shop load plan should be automated as a standard report in the CMMS. A single database should support all three levels of scheduling (i.e., shop load plan, master schedule, and shop schedule) in a networked system. While it is possible to examine the shop load plan on a video display

terminal, the practical limitation on the number of lines and columns that can be displayed at one time makes a printout on wide paper convenient for use by managers.

4.2 DATA ELEMENTS

The following data elements are shown on the Shop Load Plan. The information either is contained in the CMMS database or is derived from the CMMS database. It is defined below as an aid to understanding the schedule format. The only item that should require entry in the scheduling process is for the scheduling period. The rest of the information is based on other data entered in the CMMS during the work reception and planning process or extracted from other databases, such as labor accounting.

1. **Period Covered:** The time period this schedule considers. Normally, for the Shop Load Plan this is a quarter; however, the immediate next three months may be subdivided into a one-month short term and a 2-month midterm load plan for additional scheduling control.
2. **Shop:** The shop or craft group being scheduled; e.g., carpenters. (The sample form shows 12; this should be adjusted to meet local needs.)
3. **No. of Employees:** The average number of employees available in each shop for the schedule period.
4. **Gross Work Hours Avail:** The total number of man-hours available in each shop during the schedule period.
5. **Adjustments:** The number of man-hours that will not be available in each shop for facilities maintenance work due to leave, training, jury duty, and similar non-production activities. (This may be presented on more than one line if it is desired to have a line for each type of adjustment.)
6. **Net Work Hours Avail:** The net man-hours available in each shop for facilities maintenance work, computed as item 4 less item 5.
7. **TC LOE:** Trouble Call ticket level of effort, the number of hours allocated by shop for jobs issued under Trouble Call tickets. Usually, this is based on past experience.
8. **PM Scheduled:** The number of hours for scheduled PM work by shop. This is determined from the PM schedule contained in the CMMS database.
9. **PT&I Scheduled:** The number of hours for scheduled PT&I work by shop. This is determined from the PT&I schedule contained in the CMMS database.
10. **Scheduled, Recurring:** The number of hours by shop for other scheduled recurring work. This may be determined from the CMMS database. It may be presented on more than one line if grouped by type, work order, etc.

- | | |
|-----------------------------------|---|
| 11. Total LOE, Scheduled, etc. | Total hours committed to items 7, 8, 9 and 10 above. |
| 12. Carry-over from prior period: | Work scheduled or started in the prior period, but not completed, and thus, carried over to this period. This may be automatically computed by comparing work order labor estimates against labor charges to-date. |
| 13. Available to Schedule: | Net Work Hours available (6) less item Total LOE, Scheduled, etc. (11), and Carry-over (12). This is the work force available for scheduling new work orders. |
| 14. W.O. #: | Work Order number for each work order listed. |
| 15. Description: | An entry giving a short title for each work order. The number of hours estimated for each shop for the work order follows on the same line. |
| 16. RSD: | Requested start date for the work order. |
| 17. RCD: | Required completion date for the work order. |
| 18. PRI: | Priority of the work order. |
| 19. MAT: | Material status indicator. Normally, this block contains the date on which the required material is expected to be available, or that the material is available. This is the overall status of the field "Avail" on the Work Order Material/Equipment Requirements form, Figure D-5.) |
| 20. Work Hours: | The estimated work hours for the work order for each shop. |
| 21. Total | The total labor hours for the work order for all shops. |
| 22. Labor: | Estimated total labor cost for the work order. |
| 23. Mtl.: | Estimated total material cost for the work order. |
| 24. Other: | Estimated total other cost for the work order. This would include items such as equipment rentals and contracted services. |
| 25. Total: | The total cost for the work order |

4.3 INSTRUCTIONS FOR USE

Normally, the shop load plan is prepared covering a quarter. However, shop load plans should be prepared and maintained looking 18 months into the future. The last period should include all work that is in an "estimated and approved but unscheduled" status. A Field Installation also may wish to extract a short term (next month) and a midterm (following two months) shop load plan for closer work scheduling and management. After final approval of a work order, it is assigned to a shop load plan. Normally, this level of scheduling is done by a senior maintenance planner, not in the shops organization. This starts the work performance phase and triggers material acquisition to ensure that the required material is available for the assigned start period. Approved work orders remain in the shop load plan until completed or canceled.

The primary purpose of the shop load plan is to provide for the orderly scheduling of work in accordance with the Field Installation's mission priorities, to assist in resource scheduling and management, and to provide senior managers with information on pending work. It also

provides a valuable tool for evaluating the work force skill mix against workload requirements. If the shop load plan consistently shows a significant amount of over scheduling or unscheduled backlog in a shop coupled with under scheduling in another shop, realignment of work force assets from the under-scheduled to the over-scheduled shop may be in order.

5. MASTER SCHEDULE

5.1 SAMPLE FORM: MASTER SCHEDULE

Figure D-7 (see fold-out page at the end of this appendix) is a sample form for a master schedule. The master schedule is based on the shop load plan. However, its focus is on scheduling work performance to a specific week and tracking material status of work orders that are due for master scheduling in the future according to the current and approaching shop load plans. Normally, master schedules are prepared covering 6 to 10 weeks into the future. Jobs with long-lead time material requirements may be scheduled further in the future. Of special interest is the Work Orders Waiting Material section. This is used to highlight the material status of work orders waiting material that need to start during the master schedule period covered.

5.2 DATA ELEMENTS

The following data elements are shown on the master schedule form. As with the shop load plan, the information either is contained in the CMMS database or is derived from the CMMS database by manipulation and calculation. The data elements are defined below as an aid to understanding the schedule form. The only data that should require entry in the scheduling process is for the period during which the work order is being scheduled (normally, the specific work week). The rest is based on other data entered in the CMMS during the work reception and planning process, the material management process, or extracted from other databases such as labor accounting.

1. Period Covered: The time period this schedule considers. Normally, for the master schedule this is a work week.
2. Shop: The shop or craft group being scheduled; e.g., shop 01, carpenters.
3. No. of Employees: The average onboard manpower in each shop during the schedule period.
4. Gross Work Hours Avail: The total number of man-hours in each shop available during this period.
5. Adjustments: The number of man-hours that will not be available for facilities maintenance work due to leave, training, jury duty, and similar nonproduction activities. This may be presented on more than one line if it is desired to have a line for each type of adjustment.
6. Net Work Hours Avail: The net available man-hours for facilities maintenance work

- 7. TC LOE: Trouble Call ticket level-of-effort, the number of hours allocated for jobs, usually issued under Trouble Call tickets. Usually, this is based on past experience.
- 8. PM Scheduled: The number of hours for scheduled PM work.
- 9. PT&I Scheduled: The number of hours for scheduled PT&I work.
- 10. Scheduled & Recurring: The number of hours for other scheduled or recurring work. This may be presented on more than one line if grouped by type, work order, etc.
- 11. Total LOE, Scheduled, etc. Total hours committed to items 7, 8, 9. and 10.
- 12. Available to Schedule: Net Work Hours Available (item 6) less item 11. This is the work force available for scheduling specific work orders.
- 13. W.O. #: Work Order number for each specific work order listed.
- 14. Description: Entry giving a short title for each work order. Also, the number of work hours scheduled for the work order by each shop during this schedule period are entered under the shop number on the same line.
- 15. RSD: Requested start date for the work order.
- 16. RCD: Requested completion date for the work order.
- 17. PRI: The work order priority rating.
- 18. MAT: Material status indicator. Normally, this entry is the date on which material required for the work order is expected to be available, or a code indicating that the material is currently available.
- 19. Total: Total labor hours for the shops.
- 20. Labor: Expended labor hours. The total labor hours used or scheduled for the work order prior to this schedule period.
- 21. Mtl.: Cumulative material cost of material used for work order.
- 22. Other: Cumulative costs of other than labor and material used for the work order. This includes such items as equipment rentals and contracted services.
- 23. Total: Cumulative total cost.

5.3 INSTRUCTIONS FOR USE

The master schedule is used to direct and coordinate the execution of work in the shops. It provides the coordinating linkage between the shops on jobs involving more than one shop, and it highlights the material status of pending work orders. Normally, it is maintained under the direction of the shops supervisor working in close coordination with the shop supervisors and the maintenance planners. Work is scheduled by assigning it to a week; the automation program used should perform all necessary calculations including computing estimated carryover work and resources expended (or projected to be expended) up to the period under consideration.

It is essential that the master schedule give close attention to balancing the work to each shop to ensure that all forces are productively employed. To this end the master scheduler will assign labor hours to each scheduled job within available manpower and job phasing requirements.

While it is possible to examine the master schedule on a video display terminal, the practical limitation on the number of lines and columns that can be displayed at one time makes it difficult to see all work that is subject to scheduling. Accordingly, printouts on wide paper and wall-mounted scheduling boards normally are used to display job status.

6. SHOP SCHEDULE

6.1 SAMPLE FORM: SHOP SCHEDULE

A form for a shop schedule is provided as Figure D-8 (see foldout page at the end of this appendix). The shop schedule provides the day-to-day scheduling/assignment of workers and equipment to work orders. It is used by the shop supervisor as an aid in scheduling his personnel and shared equipment assets.

6.2 DATA ELEMENTS

The following data elements are shown on the Shop Schedule form. The information either is contained in the CMMS database or is derived from the CMMS database by manipulation and calculation. The data elements are defined below as an aid to understanding the schedule form. The only data elements that should be entered during the scheduling process are the assigned hours for each work order and employee being scheduled. The remaining data elements should be provided by the computer based on other data entered in the CMMS during the work reception and planning process, the material management process, or extracted from other databases.

- | | |
|----------------------------|--|
| 1. Period Covered: | The time period this schedule considers. Normally, for the shop schedule it is a specific day. |
| 2. Shop: | The shop or craft group being scheduled; e.g., shop 01, carpenters. |
| 3. Employee: | The name or other identifier of the worker being scheduled. |
| 4. Gross Work Hours Avail: | The total number of man-hours available for each worker during this period, normally eight. |
| 5. Adjustments: | The number of man-hours that will not be available for facilities maintenance work due to leave, training, jury duty, and similar nonproduction activities. This may be presented on more than one line if it is desired to have a line for each type of adjustment. |
| 6. Net Work Hrs. Avail: | The net available man-hours for each employee for facilities maintenance work. |
| 7. W.O. #: | Work order number for each work order listed. |

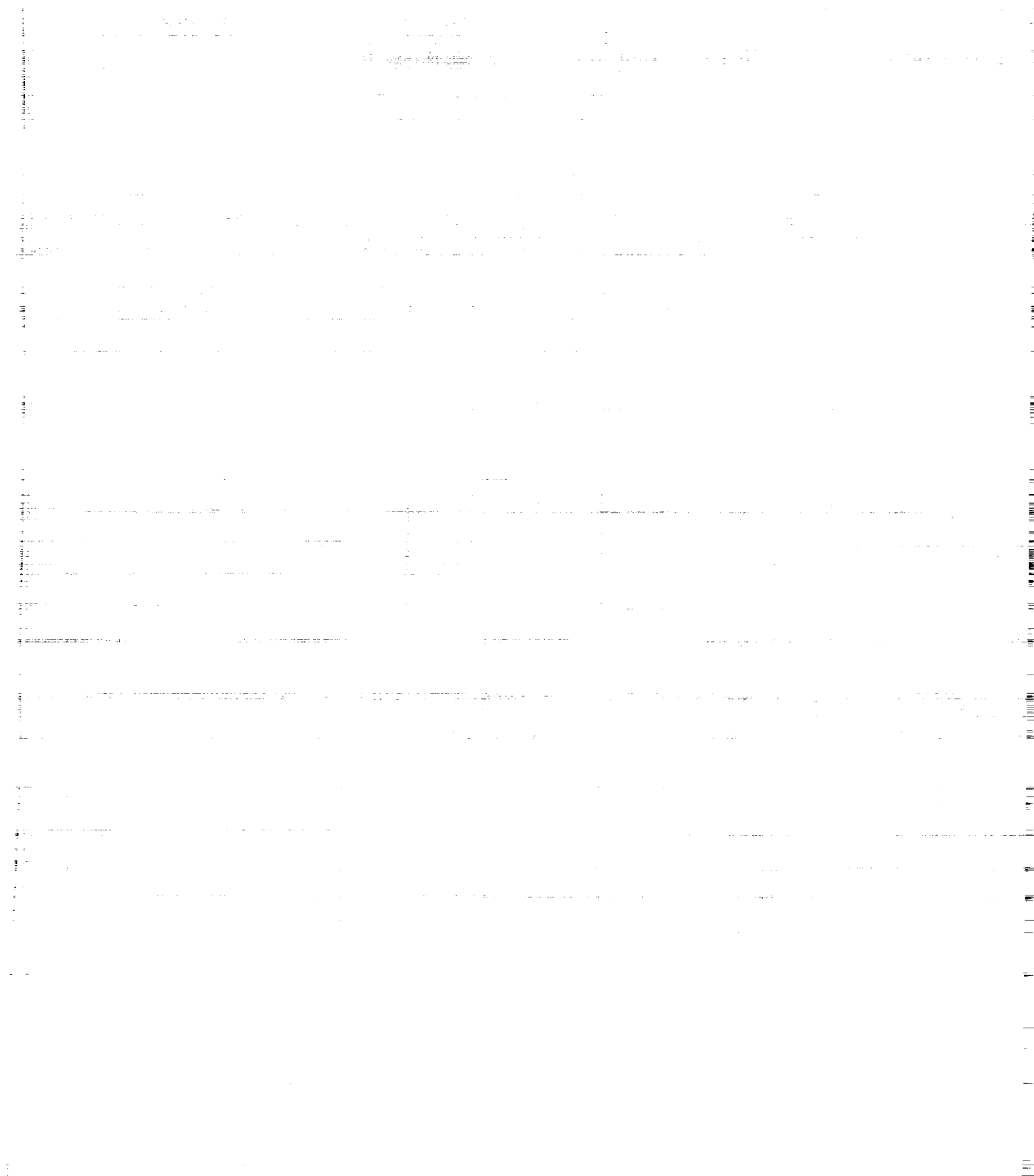
- 8. Description: An entry giving a short title for each work order. The hours assigned to each employee for each work order number follow on the same line under the employee's identification.
- 9. RSD: Requested start date for the work order.
- 10. RCD: Requested completion date for the work order.
- 11. PRI: The work order priority rating.
- 12. MAT: Material status indicator. Normally, this is a code or symbol indicating that the material is currently available.
- 13. Total: Total hours for all employees.
- 14. Labor: Cumulative labor hours for the work order prior to this schedule period. This information is provided as part of the labor distribution/timekeeping process.
- 15. Mtl.: Cumulative cost of material used for the work order.
- 16. Other: Cumulative cost of other than labor and material used for the work order. This includes such items as equipment rentals and contracted services.
- 17. Total: Cumulative total cost.

6.3 INSTRUCTIONS FOR USE

The shop schedule is used by the shop supervisor in scheduling and managing his craftsmen. It is typically prepared on a weekly basis for each day of the following week, based on jobs scheduled in the master schedule. The shop supervisor enters the hours each employee is scheduled to work on each assigned job for each day. The work force availability is determined from leave, training, and related activities that are also scheduled through the shop supervisor.

[illegible][illegible][illegible]

Figure D-7. Sample Form: Master Schedule



FOLDOUT FRAME 1.

PERIOD COVERED: (1)						MASTER				
SPECIFIC WORK/ITEM										
WORK FORCE AVAILABILITY	(2) SHOP ->					01	02	03	04	05
	No. of Employees	(3)								
	Gross Work Hours Avail.	(4)								
	Adjustments	(5)								
	Net Work Hours Avail.	(6)								

W.O. #	DESCRIPTION	RSD	RCD	PRI	MAT	01	02	03	04	05
COMMITTED WORK FORCE	TC LOE	(7)								
	PM Scheduled	(8)								
	PT&I Scheduled	(9)								
	Scheduled & Recurring	(10)								
	Total LOE, Scheduled, etc.	(11)								
	AVAILABLE TO SCHEDULE	(12)								
(13)	(14)	(15)	(16)	(17)	(18)					
	[list specific work orders]									
	[as many lines as needed]									
	Net hours over/under scheduled									

WORK ORDER										
	[as many lines as needed]									
	Total waiting material									

FOLDOUT FRAME 2.

PRECEDING PAGE BLANK NOT FILMED

SCHEDULE

For SHOP (2)

WORK HOURS

USED

REMARKS

Total

Total

Labor

Mtl.

Other

Total

(13)

(14)

(15)

(16)

(17)

Figure D-8. Sample Form: Shop Schedule

1. The first part of the document is a list of the names of the members of the committee.

2. The second part of the document is a list of the names of the members of the committee.

3. The third part of the document is a list of the names of the members of the committee.

4. The fourth part of the document is a list of the names of the members of the committee.

5. The fifth part of the document is a list of the names of the members of the committee.

6. The sixth part of the document is a list of the names of the members of the committee.

7. The seventh part of the document is a list of the names of the members of the committee.

8. The eighth part of the document is a list of the names of the members of the committee.

9. The ninth part of the document is a list of the names of the members of the committee.

FOLDOUT FRAME 1.

PERIOD COVERED: (1)						SHOP					
SPECIFIC WORK/ITEM						W					
(3) EMPLOYEE ->											
Gross Work Hours Avail. (4)											
Adjustments (5)											
Net Work Hours Avail. (6)											

W.O. #	DESCRIPTION	RSD	RCD	PRI	MAT						
(7)	(8)	(9)	(10)	(11)	(12)						
	[assigned work orders]										
	[as many lines as needed]										
Net hours over/under scheduled											

FOLDOUT FRAME 2.

PRECEDING PAGE BLANK NOT FILMED

FOLDOUT FRAME

PERIOD COVERED: (1)										SHOP L					
SPECIFIC WORK/ITEM										WC					
WORK FORCE AVAILABILITY	(2) SHOP ->									01	02	03	04	05	06
	No. of Employees (3)														
	Gross Work Hours Avail. (4)														
	Adjustments (5)														
	Net Work Hours Avail. (6)														
W.O. #	DESCRIPTION	RSD	RCD	PRI	MAT	01	02	03	04	05	06				
COMMITTED WORK FORCE	TC LOE (7)														
	PM Scheduled (8)														
	PT&I Scheduled (9)														
	Scheduled, Recurring (10)														
	Total LOE, Scheduled, etc. (11)														
	Carry-over from Prior Period (12)														
	AVAILABLE TO SCHEDULE (13)														
(14)	(15)	(16)	(17)	(18)	(19)	(20)									
	[list specific work orders]														
	[as many lines as needed]														
Net hours over/under scheduled															

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APPENDIX E

CMMS EVALUATION AND SELECTION GUIDE

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APPENDIX E

CMMS EVALUATION AND SELECTION GUIDE

1. INTRODUCTION

This guide is an aid for use in evaluating and selecting a Computerized Maintenance Management System (CMMS). It provides, in summary form, a number of factors that should be considered during the process and a guide to the meaning or importance of each factor. The factors listed represent a comprehensive idealized CMMS. Not all factors will be applicable to all cases and Field Installations. Also, additional factors may be added to meet local needs. Weighting for each factor should be determined on an individual basis for the Field Installation based on its needs. Few if any CMMS will meet all factors, and many will only support a few of the functions listed. However, it may be possible to combine a CMMS with a CMMS-related product to provide the needed functionality. The ultimate selection must be based on that system which best meets the Field Installation's needs.

The Figures E-1 through E-5 checklists provide a convenient way to display a summary of competing CMMS in tabular form to compare the relative merits of the systems. Much of the information can be derived from the CMMS's specifications. New CMMS products are frequently reviewed in the maintenance management and plant engineering technical journals and the trade press. The published reviews range from a summary of vendor-supplied data to the results of hands-on tests of CMMS's. The selection process should include a search of recent technical journals

and trade publications for such reviews. Table E-1 provides a listing of several publications that may contain reviews of CMMS's. CMMS vendors will often provide information on reviews of their products, especially if favorable. In addition, most CMMS vendors offer demonstration disks or evaluation copies of their products.

It should be noted that specifications, trade publication reviews, demonstration disks, and evaluation copies do not always reflect system performance when fully implemented with real data and a large inventory of facilities, collateral equipment, and facilities maintenance requirements, nor will they always reflect end-use conditions and requirements at a Field Installation. System responsiveness, speed, and convenience of use may not be the same. Therefore, evaluations and opinions from existing users of the CMMS under consideration, supplemented by site visits to locations where the system is in use, will provide valuable insight. However, there is no substitute for hands-on test and evaluation of a system with the Field Installation's data. To the extent possible, all prospective users of the CMMS should provide input to the evaluation process.

For purposes of this guide, CMMS evaluation factors are grouped into four categories:

- Maintenance management functions.
- Program features.
- Operating environment.
- Vendor/developer data.

PUBLICATIONS CONTAINING CMMS REVIEWS/INFORMATION

This is a partial listing of publications that contain reviews of CMMS or articles on CMMS. A search of back issues may provide insight into the capabilities of different CMMS products. Caution should be used when reviewing information in the publications because software products are frequently updated adding new features and capabilities. The information or review in the publication may NOT reflect the product's current capability. Be sure to check the date of the publication and the release or version number of the CMMS program being reviewed. This is not an endorsement of the listed publications; users of this guide should consider other publications as well. Vendors of CMMS may provide listings or copies of reviews of their products if asked.

Intertec Publishing Corp., *Engineer's Digest*, 9221 Quivira, Overland Park, KS 66215.

American Institute of Plant Engineers (AIPE), *AIPE Facilities Management, Operations & Engineering*, 3975 Erie Ave., Cincinnati, OH 45208.

Association of Physical Plant Administrators of Universities and Colleges, *Facilities Manager*, 1446 Duke St., Alexandria, VA 22314.

American Hospital Publishing, Inc., *Health Facilities Management*, 211 E. Chicago Ave., Suite 700, Chicago, IL 60611.

Applied Technology Publications, *Maintenance Technology Magazine*, 1300 S. Grove, Barrington, IL 60010.

Cahners Publishing Company, *Plant Engineering*, 1350 E. Touhy Ave., Des Plaines, IL 60081.

Putman Publishing Company, *Plant Services*, 301 E. Erie St., Chicago, IL 60611.

Thomas Marketing Information Center, *1991 CMMS DIRECTORY AND COMPARISON GUIDE*, Five Penn Plaza, 8th Floor, New York, NY 10001.

Table E-1. Publications Containing CMMS Reviews/Information

Each is discussed below, followed by sample evaluation sheets (Figures E-1 through E-4) listing the factors in each category. A blank evaluation sheet (Figure E-5) is also provided for locally identified factors.

2. MAINTENANCE MANAGEMENT FUNCTIONS

This group reflects the heart of the CMMS and its potential utility to the Field Installation. This section, coupled with Section II, Program Features, should be the primary basis for CMMS selection. Facilities maintenance management functions would tend to be a pass/fail criteria for a CMMS, depending on the presence or absence of a required function. Chapters 5 and 6 should be reviewed in detail for further information on key CMMS functions and facilities maintenance management. The following are suggested as a basis for evaluation.

2.1 Inventory Database Management. This is the heart of any facilities maintenance management system. The CMMS must permit recording necessary information for each facility and collateral equipment item. It must provide for a unique identifier for each maintained item and should permit grouping items by systems and sub-systems as well as providing for the usual make, model, location, custody, facilities maintenance standards reference, facilities maintenance requirements reference, financial information, and standard reports. Check to ensure that the CMMS provides for recording the data elements required by Field Installation management and has the required capacity. Chapter 8 provides further information on facilities and collateral equipment inventory.

2.2 Continuous Inspection. The continuous inspection function should provide for condition assessment inspection of all facilities and collateral equipment contained in the inventory on a scheduled basis. It should schedule inspections to a specific time period, typically a month, and provide summary schedules and resource requirements reports. It should permit each facility or collateral equipment item to have an individually determined inspection schedule or frequency. It should provide inspection checklists and guides for the inspector, including appropriate facilities maintenance standards and drawings, prior inspection results, current or pending work orders and work requests for the system being inspected, information on future plans for use of the system, and safety and coordination requirements. It should identify specialized inspections.

2.3 Preventive Maintenance. A CMMS should provide complete PM scheduling and PM order preparation, based on the inventory and facilities maintenance requirements entered into the system. This includes multiple levels of scheduling based on use, condition, or calendar time. The system should couple inventory data, facilities maintenance checklist, parts required, safety requirements, coordination/outage requirements, results of last PM, diagnostic and maintenance references, drawings, special tool or equipment requirements, and special skill or trade requirements in the process. It should permit scheduling to the week and it should be able to give resource requirement reports and summary schedules.

2.4 Predictive Testing & Inspection (PT&I). The CMMS should provide for Predictive Testing and Inspection. This should include information similar to con-

tinuous inspection above and include the ability to project trends in test results or use and schedule facilities maintenance actions such as PM or further inspection based on the trends. Check for close integration with hardware and software interface specifications for PT&I.

2.5 Work Order Tracking. The CMMS must provide the capability to track the receipt of a request for facilities maintenance work or work requirement received from any source through final completion. This includes its progress through planning and estimating, scheduling, execution by in-house shops or contractor forces, as well as any administrative or planning actions undertaken, such as waiting for funding or incorporation into a CoF project. The system should permit full inclusion of the data the Field Installation requires for requests for facilities maintenance work and work orders.

2.6 Trouble Calls. The CMMS should permit receipt and issue of Trouble Calls. Appendix D provides a sample Trouble Call ticket that can be used as a guide for evaluation of CMMS. The system should accommodate all data tracked by the Field Installation's Trouble Call ticket control system. It also should provide the status of Trouble Call tickets pending action, underway, and completed.

2.7 Other Work Orders for Repair, PM, ROI, etc. The CMMS should provide for preparation of specific or one-time work orders for Repair, PGM, ROI and other work that is of fixed duration and scope. This should be integrated with work order estimating and scheduling. Appendix D provides a sample work order that may be used as an aid in judging CMMS.

2.8 Work Order Estimating. The CMMS should provide for an integrated work order estimating system. The system should provide planners and estimators with comprehensive assistance in preparing work order craft, time, and material estimates. It should permit including local labor and material rates, local unique cost factors, or standard work tasks. Although there are many computer-aided estimating systems currently available, commercial and government developed, integration with CMMS is not widespread at the time of this handbook preparation.

2.9 Facilities Maintenance History. The CMMS should provide for fully documenting the facility maintenance history, to include summaries of all actions related to the facility. This includes Trouble Calls, specific Service Requests, work orders, PM history, alterations, modifications and improvements, and inspection results.

2.10 Material Management. Material management functions should provide for material inventory (including high and low limits), ordering based on the low limit and new work orders, order tracking, receiving, issue, reservations against work orders, and material status for work order scheduling. It may include vendor and price data for stocked materials and information on purchase agreements. Memorandum financial accounting for material purchases is desirable.

2.11 Tool and Equipment Management. Tool and equipment management functions should support central tool room operations including issue, inventory, and accountability for specialized tools and related maintenance equipment. Tool and equipment

management functions are not considered vital to a CMMS.

2.12 Scheduling. A good CMMS will provide comprehensive scheduling support. In addition to scheduling inspections and PM noted above, it will facilitate scheduling specific work orders. The CMMS should support the levels of scheduling used at the Field Installation, integrate with material management functions, and provide for workload and work force balancing.

2.13 Backlog of Deferred Facilities Maintenance. The system should permit developing a backlog of deferred facilities maintenance based on condition assessment. This backlog should be constructed as discussed in Chapter 4 of the manual, reflecting the Annual Work Plan.

2.14 Contract Administration. Because a significant portion of the Field Installation work is accomplished by contract, a CMMS should provide support for contract preparation and administration, including tracking delivery orders, modifications, and payments. Chapter 14 provides information on contractual support.

2.15 Utilities. A comprehensive CMMS will support utilities operation and management, including estimating, reporting, and model generation and use. See handbook Chapter 9 for more information on energy and utilities management data processing requirements.

2.16 Environmental Tracking. Environmental tracking and management is an area of great political sensitivity. The CMMS should facilitate necessary tracking, reporting, and historical record functions. Chap-

ter 14 provides additional information on environmental compliance.

2.17 CADD. CADD support is desirable; however, it was not commonly found in CMMS as this handbook went to press.

2.18 Priority System. The CMMS should provide for assigning work priorities in accordance with the Field Installation's system and using these priorities in any automated scheduling schemes employed.

2.19 Warranty Tracking. The CMMS should include provisions for tracking warranties on facilities and collateral equipment. It should alert users when work orders (including Service Requests and Trouble Calls) are entered on covered equipment within the warranty period, track requested warranty work, and accommodate tiered warranties and multiple warranties with different expiration dates on the same item.

2.20 Management Reports. The CMMS should provide management reporting keyed to the Field Installation manager's needs as well as to facilities maintenance operations. This relates closely to the customization and ad hoc query features discussed in section 2 below.

3. PROGRAM FEATURES.

Program features reflect variations on how the facilities maintenance management functions are implemented, options to configure the database, and integration with other facilities maintenance management functions and processes. Program features evaluation can be used to differentiate among similar CMMS systems. The following program features should be examined.

3.1 User Customization. The system should permit authorized Field Installation personnel to modify, add, or delete reports, forms, screens, data elements, data definitions, and other features to meet local needs. This may be provided through a "tool box" utility, sometimes offered at extra cost. The extent of customization permitted should be considered in the evaluation.

3.2 Ad Hoc Query. An example of an ad hoc query would be "List all work orders completed in 1990 on building 321 that cost more than \$3000 and involved Repair". The ability for a user to perform this type of specialized or one-time query without having to create a new report is an important feature. This should be easily accomplished, permit use of multiple conditions, and support use of information from several related data files.

3.3 Data Exchange. The ability of the CMMS to directly exchange data with its modules and other programs and systems should be examined. Methods include direct access of files on a network and connection via data or phone lines. The ability to establish direct communication with portable computers used by field personnel is a strong point. The ability to access Field Installation financial, personnel, accounting, supply, and other related automated systems is also important.

3.4 Presentation Graphics. Presentation graphics is the capability of the program to produce charts and graphs based on information drawn from the database. This may be accomplished directly in the CMMS program or through a linkage with a graphics program. A common means of linkage is through creation of a file that is readable by a third-party presentation graphics program.

The ease with which graphics can be produced and annotated to serve management needs is the prime consideration here.

3.5 Modules. The ability to install a CMMS in modules, implementing only those functions required at a given point in time, may be an advantage to a Field Installation. This permits phased implementation and may reduce costs by avoiding payment for functions that will not be used. The modular nature of the software program should be explored.

3.6 System Utilities. The CMMS should provide ready access to system utilities for purposes such as formatting diskettes, moving or copying files, and other common functions. These may be implemented as a program feature, or through access to the operating system. They should be easy to use, returning the user to the point in the CMMS where they were called.

3.7 Child Processes. A "child process" is a second program that is started from within another program; for example, calling a word processor to prepare and print a memorandum from the CMMS system, and returning to the calling point in the CMMS when the memo is completed. This may be a desirable feature. The same functionality can be obtained through use of a multi-tasking operating system or special programs such as WINDOWS or DESQVIEW on microcomputers. The "Shell to DOS" feature found in some PC programs can also provide this service; however, memory size restrictions may limit its usefulness.

3.8 Warranty. The system warranty provisions should be clear, especially the policy for returning the software if it does not meet Field Installation requirements, and

the policy for fixing "bugs;" i.e., software performance problems. Annual support agreements may impact warranty coverage.

3.9 Integration. Integration examines the ability of the different functions of the CMMS to operate together, exchanging and sharing data, with changes entered in one function appearing in the output of another without user intervention. For example, recording the receipt of ordered material should update the status of all work orders on hold waiting for that material, adjust stock levels, and mark the order as filled. A CMMS must have tight integration, especially in the work order preparation, scheduling, and tracking areas and in the facility inventory, PM, and inspection areas.

3.10 Transaction Recording. A log of CMMS use and changes to data may prove valuable as an audit trail and system evaluation tool. The detail presented could range from log-in/log-out data to full "keystroke recording." This should be examined against Field Installation needs.

3.11 Data Import. The CMMS should have the ability to read and load data from standard file formats. The ability to extract user-specified portions of data from a file is important as this can speed data loading. Some standard, common industry formats include ASCII, Delimited ASCII, DBF (data base file format used by Ashton Tate's dBASE series of database programs), WKS or WK1 (used by LOTUS 1-2-3 spreadsheet programs), for data and DXF (drawing exchange format, used by AUTODESK's AUTOCAD program) for CAD drawings. Other CAD drawing formats, such as INTERGRAPH's or COMPUTERVISION's may be converted through IGES (Initial Graphics Exchange Specification)-based

translators. Formats beyond those used at the Field Installation may be of limited value. However, support for file formats currently in wide use at a Field Installation is an advantage.

3.12 Data Export. The CMMS should have the ability to export all (or user-selected portions) of the database in standard file formats. See Data Import, above.

3.13 Archive. The CMMS should have the capability to archive inactive records and data based on user-selected criteria. For example, a Field Installation may wish to remove information on work orders that have been completed for over 2 years from the active data files, but still have the information available for off-line reference. Archiving systems should provide the means to view and retrieve the data. Care should be taken not to archive essential facility history data.

3.14 Back-up. The CMMS should have automated data back-up and recovery features. This should support multiple media types. (Magnetic tape and floppy diskettes are in common use in microcomputers at this writing.)

3.15 Number of Users. Software is typically licensed for a specified number of users or for use on a specified number of computers. Programs designed to operate on a network may limit the number of simultaneous users. The capability of the program should be determined. CMMS cost may vary with the number of users. It should be possible to add additional users at a later date if expansion is required.

3.16 Capacity. Capacity refers to the number of entries or records (and the maxi-

mum size of each record) that are permitted in each of the databases of the CMMS. The better CMMSs permit a number of records that is limited only by mass storage. However, some systems may be limited or require the purchase of modules adding capacity. The CMMS should have sufficient capacity in each function to accommodate the Field Installation's facilities maintenance management requirements, including projected growth.

3.17 Speed. Speed refers to how quickly the CMMS can perform required operations on the database. Such operations include preparation of reports, printing PM schedules and PM work orders or cards, searching the database for the status of a work order, responding to an ad hoc query, or preparing an estimate using the work order estimating database. Speed tends to degrade as the size of the database increases and as the number of simultaneous users increases. Systems perceived as slow by users will fall into disfavor and should be avoided. Speed is very dependent on the hardware used for the CMMS as well as on the data structure and software. To the maximum extent possible, speed evaluations should be based on tests using the hardware configuration, database size, and operations planned for the installed CMMS.

3.18 User Help/Documentation. The CMMS should provide an adequate level of documentation and an effective on-line help system to assist users after initial training and installation. Documentation should be clear, concise, and comprehensive, covering all aspects of the CMMS. The on-line help facility should be available at all times and should be context sensitive, providing assistance and suggestions to the user for the current operation. A user should be able to

find the answer to most routine questions in the on-line help module. The ability to edit or add to help screens is an advantage.

3.19 Menus/Interface. This factor examines the user interface. The CMMS should provide an easy, logical flow from one operation to another permitting rapid, direct movement by expert users as well as providing a methodical menu system for less experienced users. Use of the keyboard, mouse, digitizer, light pen, track ball, or touch-screen are possible methods to access menu items. As many of the principal users as possible should examine a prospective CMMS in this area. The ability of the user to build custom menus is a desirable feature.

3.20 Error Handling. The CMMS should provide comprehensive error handling. This includes a capability for data validation; i.e., checking against limits or a list of permitted entries. It should also protect the data from abnormal situations, giving the user the opportunity to correct situations such as a printer out of paper or off-line, floppy disk missing, telephone connection lost, drive error, or similar event. Error conditions should be "trapped" and informative error messages given to the user, permitting the user to save current data and exit the program if necessary. Data deletion should be subject to verification.

3.21 Password Protection. The CMMS should have levels of password protection to control the ability to view only, modify, enter, and delete data. It should also control system changes such as creating and modifying reports, forms, and data structure. This should apply to each of the several functions and databases.

3.22 Cost. In evaluating cost, be sure to consider CMMS modules and options within functions as well as any recurring system maintenance or support costs.

4. OPERATING ENVIRONMENT

The operating environment reflects the required hardware, operating system, and facility support for the CMMS. This may be a significant first cost compared to the cost of CMMS software, and it may be an important factor if the CMMS is planned for an existing suite of hardware. However, considering the life cycle cost of facility maintenance management, this would not normally be the deciding factor. The following environmental factors should be examined.

4.1 Hardware Platform. This is the computer type or types on which the CMMS may be operated. Some CMMS may be limited to one vendor's product or standard while others may operate on a broad range of systems. Within this factor there may be a range of central processor units (e.g., Intel 80286 or higher but not Intel 8088, or Motorola 68010 but not Motorola 68000) and processor speeds that are recommended for satisfactory operation. Although excellent performance can be obtained with CMMS operating on microcomputer-based systems (and a wide variety of CMMS products support PC hardware) systems are also available for work station and minicomputer-based systems, such as those produced by SUN, Honeywell, or Digital Equipment Corporation (DEC).

4.2 Operating System. This is the core program that provides the software communication interface between the manufacturer's hardware and the developer's software.

It is typically unique to a given computer hardware set. Some common examples used on microcomputers are MS/DOS, PC/DOS, DR DOS, PRODOS, OS/2, and UNIX. Within operating systems, there are various release levels. For example, MS/DOS release 3.3 supports a substantially greater capability than release 2.1, and a program requiring release 3.3 will not operate on release 2.1. It is an advantage to have an operating system and hardware platform that are widely supported by software vendors. Some CMMS may be available for more than one operating system. Some hardware platforms may use a proprietary operating system. This could mean limited third party software support. Operating systems may be single task (can only operate one program at a time) or multi-tasking (permit the operator to run several programs at the same time). Multi-tasking may be an advantage, but is usually more costly.

4.3 Network Capability. This should indicate if the CMMS will operate on a networked system, allowing shared files and simultaneous users. There are several network systems in common use. The networking systems supported should be listed. Broad support is desirable, but a CMMS need not support systems beyond those installed or planned at a Field Installation.

4.4 Memory Requirements. For each program there is a certain minimum amount of primary storage or random access memory (RAM) that must be available for the program to operate. There may be a larger amount recommended for optimum operation. Less than the optimum amount may slow operations substantially. RAM requirements should be a significant factor only when a CMMS is being selected to

operate on an existing system that is limited in the amount of RAM it can accommodate.

4.5 Mass Storage Requirements. Mass storage commonly refers to disk drive space available for storage of program and data files. The amount required will depend on the size of the database and how the CMMS uses the storage space. Storage capacity of disk systems is an area of rapid technological advancement. It should be investigated to ensure that adequate storage is available.

4.6 Supporting Software Requirements. Some CMMS also may require other supporting software. This could include system interface programs, such as WINDOWS or GEM, or special programs called "drivers" to permit communication with input or output devices. Normally, these would be provided with the CMMS (possibly at additional cost). The requirement should be investigated, but it should not be a significant factor in the selection process.

4.7 Input/Output Support. The ability of the CMMS to support the desired range of input and output devices should be evaluated. Typical devices include a mouse, digitizing tablet, modem, light pen, optical disk, bar code readers, floppy disk, laser printer, dot matrix printer, back-up media, and plotter. Special software drivers are often required for different brands and models of printers and plotters. These are usually built into the software, but may be provided as part of supporting software such as with WINDOWS. This may be a significant evaluation factor.

4.8 Physical Environment. This factor normally applies to the selection of hardware, but it also is listed here for consideration if hardware procurement is planned.

Any special environmental considerations such as temperature, humidity, power conditioning, floor space, or security should be investigated. If sensitive information will be stored in the CMMS, physical security may be a factor.

5. VENDOR/DEVELOPER DATA

Vendor (or developer) data provides information on the supplier. It may provide some indication of the vendor's stability and viability in the CMMS market, his understanding of facilities and collateral equipment maintenance management, and his ability to provide after-sale support into the future. The following vendor/developer information should be considered.

5.1 Years in CMMS Business. A longer term can imply a successful business that addresses the needs of the CMMS market and one that will be available to provide support into the future. However, be alert for past mergers, takeovers, or spin-offs which could distort this factor. "New" does not necessarily mean a poor product.

5.2 Date of Current and Past Releases. This gives an idea as to the stability of the product and the developer's commitment to product upgrades or new features. Periodic upgrades is a good sign, but frequent updates (more often than every 12 to 24 months) might imply an unstable product or poor development practice.

5.3 Installed Customer Base. The number of users of the CMMS system is an indicator of market success and the developer's potential to stay in the CMMS market. Check to see how many sites are using the current versus prior releases. Include checking their type of business, how they are using it (e.g.,

for PM only, material management, Repair work orders, etc.), and points of contact.

5.4 Other CMMS-related Products. The vendor may offer other products related to the CMMS that would be of interest to the Field Installation; for example, utilities management, motor vehicle management and dispatch, or project management software. These may offer an advantage in terms of a common user interface, shared data, and lower first cost and support costs if bought as a package.

5.5 Other Non-CMMS Related Products. The vendor may offer other software products of value to the Field Installation. Again, economies may be available. However, normally this would not be a major evaluation factor. Also, the vendor may offer full scale systems integration services to provide a "turn-key" system including necessary hardware.

5.6 Support/Upgrade Policy. Look for a vendor that provides solid, after-market support and offers upgrades or updates at a reasonable cost. Because CMMS is not a mass market (installed bases are typically less than 1000), user support is normally not free. However, there should be a period of "free" support after installation and a warranty period to provide for adjustment if the product does not prove satisfactory in actual use.

5.7 Customized Releases. The vendor should offer customized releases structured to meet the Field Installation's unique needs. This would include modifications to screens, standard reports and forms, and data structure. Additional cost would depend on the extent of the modifications required. However, this factor is offset to some extent by

the ability to make end user modifications to the CMMS system discussed under Program Features above.

5.8 Training. The vendor should provide training support, on-site or off-site as meets the Field Installation's needs. Examine scheduling and costs. Consider the experience of current users with the training offered. Note that programs with an intuitive, user-friendly interface that conforms to a facilities maintenance management model similar to that used by the Field Installation will require less training support.

5.9 Evaluation Copy. A vendor should be willing to provide an evaluation copy for Field Installation test. A copy that limits the number of entries possible may not give a good indication of the program's performance with a large database and many users. An option to return (within, say 90 days) if not satisfied or purchase subject to approval may serve this purpose.

5.10 Installation Support. The developer should offer installation and initialization support. This may include initial data entry and conversion. Some vendors provide full scale systems integration services, including hardware procurement and setup. This will simplify the Field Installation's tasks, at some additional cost.

5.11 List of Users/References. The vendor should be willing to provide information on other users of his product whom the Field Installation can contact for first-hand impressions of the product. These references should be contacted to determine their opinions on the product and how their application matches the Field Installation's planned use. A visit to their facility to see the CMMS in operation should be made.

CMMS EVALUATION MATRIX

VENDOR ⇒ FACTOR ↓			
2.1 Inventory/ Database Management			
2.2 Continuous Inspection			
2.3 Preventive Maintenance			
2.4 Predictive Testing/Inspection			
2.5 Work Request & Work Order Tracking			
2.6 Trouble Calls			
2.7 Other Work Orders for PM, Repair, ROI, etc.			
2.8 Work Order Estimating			
2.9 Maintenance History			
2.10 Material Management			
2.11 Tool and Equipment Management			

Figure E-1. CMMS Maintenance Management Functions
(Page 1 of 2)

CMMS EVALUATION MATRIX

VENDOR ⇒ FACTOR ↓			
2.12 Scheduling			
2.13 Backlog of Deferred Facilities Maintenance			
2.14 Contract Administration			
2.15 Utilities			
2.16 Environmental Tracking			
2.17 CADD			
2.18 Priority System			
2.19 Warranty Tracking			
2.20 Management Reports			

Figure E-1. CMMS Maintenance Management Functions
(Page 2 of 2)

CMMS EVALUATION MATRIX

VENDOR ⇒ FACTOR ↓			
3.1 User Customization			
3.2 Ad Hoc Query			
3.3 Data Exchange			
3.4 Presentation Graphics			
3.5 Modules			
3.6 System Utilities			
3.7 Child Processes			
3.8 Warranty			
3.9 Integration			
3.10 Transaction Recording			
3.11 Data Import			

Figure E-2. CMMS Program Features
(Page 1 of 2)

CMMS EVALUATION MATRIX

VENDOR ⇒ FACTOR ↓			
3.12 Data Export			
3.13 Archive			
3.14 Back-up			
3.15 Number of Users			
3.16 Capacity			
3.17 Speed			
3.18 User Help/ Documentation			
3.19 Menus Interface			
3.20 Error Handling			
3.21 Password Protection			
3.22 Cost			

Figure E-2. CMMS Program Features
(Page 2 of 2)

CMMS EVALUATION MATRIX

VENDOR ⇒ FACTOR ↓			
4.1 Hardware Platform			
4.2 Operating System			
4.3 Network Capability.			
4.4 Memory Requirements			
4.5 Mass Storage Requirements			
4.6 Supporting Software Requirements			
4.7 Input/Output Support			
4.8 Physical Environment			

Figure E-3. CMMS Operating Environment Requirements

CMMS EVALUATION MATRIX

VENDOR ⇒ FACTOR ↓			
5.1 Years in CMMS Business			
5.2a Date of Prior Release			
5.2b Date of Current Release			
5.3 Installed Customer Base			
5.4 Other CMMS-related Products (list)			
5.5 Other non-CMMS-related Products (list)			
5.6 Support Upgrade Policy			
5.7 Customized Releases			
5.8 Training			
5.9 Evaluation Copy			
5.10 Installation Support			
5.11 List of Users/References			

Figure E-4. CMMS Vendor/Developer Data

[illegible]

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APPENDIX F

SOURCES OF FACILITIES MAINTENANCE STANDARDS AND PROCEDURES

TABLE OF CONTENTS

1. NASA Publications	F-1
2. Department of Defense Publications.	F-1
2.1 Naval Facilities Engineering Command Publications.	F-1
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6.1 Engineered Performance Standards (EPS).	F-9
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APPENDIX F

SOURCES OF FACILITIES MAINTENANCE STANDARDS AND PROCEDURES

1. NASA PUBLICATIONS

NMI 1710.3 Safety Program for Pressure Vessels and Pressurized Systems
NSS/GO-1740.9 NASA Safety Standard for Lifting Devices and Equipment

2. DEPARTMENT OF DEFENSE PUBLICATIONS.

2.1 NAVAL FACILITIES ENGINEERING COMMAND PUBLICATIONS.

Publications marked with an asterisk (*) are Tri-Service publications, listed under the Navy identifier. Publications are available under the listed stock number from:

Navy Publications and Forms Center
5801 Tabor Avenue
Philadelphia, PA 19120
(215) 697-2997

Since many of the publications have several stock numbers, some of which apply to document changes only, it is necessary to call the Navy Publications and Forms Center before ordering to determine the single stock number of the publication desired.

<u>Publication No.</u>	<u>Title</u>	<u>Stock No.</u>
MO-100.1*	Natural Resources - Land Management	0525-LP-173-0040
MO-100.2*	Natural Resources - Forest management	0525-LP-173-0050
MO-100.3*	Natural resources - Fish and Wildlife Management	0525-LP-173-0060
MO-100.4*	Natural Resources - Outdoor Recreation and Cultural Values	0525-LP-173-0070
MO-102*	Maintenance and Repair of Surfaced Areas	0525-LP-173-0081
MO-102.1	Asphalt Surfaced Roads and Parking Lots	
MO-102.2	Jointed Concrete Roads & Parking Lots	
MO-102.3	Asphalt Surfaced Air Fields	0525-LP-173-0100
MO-102.4	Jointed Concrete Air Fields	0525-LP-173-0110
MO-103*	Maintenance of Trackage	0525-LP-173-0117
		0525-LP-173-0118

<u>Publication No.</u>	<u>Title</u>	<u>Stock No.</u>
MO-103, CH-1	Maintenance of Trackage	0525-LP-173-0165
MO-104*	Maintenance of Waterfront Facilities	0525-LP-173-0166
		0525-LP-173-0169
		0525-LP-173-0200
MO-104.2	Specialized Underwater Waterfront Facilities Inspection	0525-LP-173-0167
MO-110*	Paints and Protective Coatings	0525-LP-173-0353
MO-111	Building Maintenance, Structures	0525-LP-173-0505
MO-111.1	Inspection of Wooden Beams and Trusses	
MO-113*	Facilities Engineering Maintenance and Repair of Roofs	0525-LP-173-0550
		0525-LP-173-0599
MO-114	Maintenance and Operations of Building Plumbing Systems	0525-LP-194-6200
		0525-LP-194-6300
		0525-LP-194-6400
MO-116	Facilities Engineering, Electrical Interior Facilities	0525-LP-173-0750
		0525-LP-173-0800
MO-117*	Maintenance of Fire Protection Systems	0525-LP-173-0810
MO-117, CH-1	Maintenance of Fire Protection Systems	0525-LP-173-0811
MO-118	Inspection of Vertical Transportation Equipment	0525-LP-001-3390
MO-119	Building Maintenance; Galley Equipment	0525-LP-173-0850
		0525-LP-173-0899
MO-124	Mooring Maintenance	0525-LP-173-1115
MO-200	Facilities Engineering; Electrical Exterior Equipment	0525-LP-173-1252
MO-201	Operation of Electrical Power Distribution Systems	0525-LP-173-1310
MO-204	Electrical Power Systems Analysis	0525-LP-173-1510
		0525-LP-173-1609
MO-205 Vol. 1	Central Heating and Steam Electric Generating Plants	0525-LP-173-1610
		0525-LP-173-1619
MO-205 Vol. 2	Central Heating and Steam Electric Generating Plants	0525-LP-173-1620
		0525-LP-173-1629
MO-205 Vol. 3	Central Heating and Steam Electric Generating Plants	0525-LP-173-1630
		0525-LP-173-1639
MO-205 Vol. 4	Central Heating and Steam Electric Generating Plants	0525-LP-173-1640
		0525-LP-173-1649
MO-205 Vol. 5	Central Heating and Steam Electric Generating Plants	0525-LP-173-1650

<u>Publication No.</u>	<u>Title</u>	<u>Stock No.</u>
MO-206	Operation and Maintenance of Air Compressor Plants	0525-LP-173-1710
MO-207	Operation and Maintenance of Internal Combustion Engines	0525-LP-173-1750
MO-207, CH-1	Operation and Maintenance of Internal Combustion Engines	0525-LP-173-1751
MO-207, CH-2	Operation and Maintenance of Internal Combustion Engines	0525-LP-173-1752
MO-209	Maintenance of Steam, Hot Water, and Compressed Air Distribution Systems	0525-LP-173-1860 0525-LP-173-1899
MO-210*	Maintenance and Operation of Water Supply, Treatment, and Distribution Systems	0525-LP-173-1950
MO-212*	Operation and Maintenance of Domestic and Industrial Wastewater Systems	0525-LP-173-1970
MO-213	Solid Waste Management	0525-LP-173-2012
MO-220*	Maintenance and Operation of Gas Systems	0525-LP-173-2210 0525-LP-173-2240
MO-221	Utilities Metering	0525-LP-001-3520
MO-225	Industrial Waste Treatment	
MO-230	Maintenance Manual Petroleum Fuel Facilities	0525-LP-173-2260
MO-300	Inactivation, Caretaker Maintenance, and Reactivation of Shore Facilities	0525-LP-173-2312 0525-LP-173-2351
MO-303	Utility Targets	0525-LP-173-2410
MO-306	Corrosion Prevention and Control	
MO-307*	Cathodic Protection Systems Maintenance	0525-LP-173-2700
MO-310	Military Entomology Operational Handbook	0525-LP-173-2770
MO-312	Wood Preservation	0525-LP-173-2835
MO-315	Pest Control Quality Assurance Evaluation	0525-LP-173-2860
MO-322 Vol. 1	Inspection of Shore Facilities	0525-LP-173-3056
MO-322 Vol. 1, CH 1	Inspection of Shore Facilities	0525-LP-173-3057
MO-322 Vol. 1, CH 2	Inspection of Shore Facilities	0525-LP-173-3059 0525-LP-173-3081
MO-322 Vol. 2	Inspection of Shore Facilities	0525-LP-173-3090 0525-LP-173-4010
MO-322 Vol. 3	Inspection of Shore Facilities	0525-LP-173-4020
MO-324	Inspection and Certification of Boilers and Un-fired Pressure Vessels	0525-LP-173-4022
MO-324, CH 1	Inspection and Certification of Boilers and Un-fired Pressure Vessels	

<u>Publication No.</u>	<u>Title</u>	<u>Stock No.</u>
MO-325	Work Simplification for Maintenance of Public Works and Public Utilities	0525-LP-173-4065
MO-327	Service Contracts; Specifications and Surveillance	0525-LP-173-5090
MO-330*	Materials Testing	0525-LP-173-5080
MO-340	Ship-to-shore Hose Handling Operations Manual	0525-LP-173-5095
MO-350	Standard Operations Manual for the Waste Oil Raft (DONUT)	0525-LP-173-7000 0525-LP-173-7050
MO-403	Navy Drivers Handbook	0525-LP-173-5200
MO-405	Maintenance and Operations of Solar Energy Systems	0525-LP-193-4800
MO-909	Oil Ship Offload Barge (SWOB)	0525-LP-173-9000
MO-910	Sewage Ship Waste Offload Barge (SWOB)	

2.2 NAVAL SEA SYSTEMS COMMAND PUBLICATIONS

Reliability-Centered Maintenance Handbook, S9081-AB-GIB-010/MAINT, 1983

2.3 U.S. ARMY ENGINEERING & HOUSING SUPPORT CENTER PUBLICATIONS

The following list of documents is an extract from the *Facilities Engineering Guidance Inventory*, TN-310-1-1, 20 June 1990, maintained by the U.S. Army Engineering and Housing Support Center. Publications are available from:

National Technical Information Service
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

<u>Publication No.</u>	<u>Title</u>	<u>Date</u>
AR 420-17	Real Property & Resource Management	76/12/13
AR 420-83	Maintenance & Services (M&S) Equipment and Facilities Engineering Shops	76/01/12
TM 5-611	Repairs and Utilities Post Engineer Shops	60/10/07
TM 5-695	Maintenance Of Fire Protection Systems	89/09/01
ADP 356-1	The Paver System User's Guide	85/00/01
ADP 356-2	Paver Reference Manual	86/00/01

<u>Publication No.</u>	<u>Title</u>	<u>Date</u>
	Surfaced Areas, Railroad, & Assoc Structures	76/03/24
R 420-72		
Paver Fd Man	Asphalt Surfaced Roads and Parking Lots	89/06/01
Paver Fd Man	Jointed Concrete Roads and Parking Lots	89/06/01
Paver Imp Br	Paver Implementation Brochure	90/05/01
Paver Misc	Nondestructive Pavement Test & Evaluation	85/01/01
aver Misc	Paver Implementation by A&E Contract	90/03/01
Paver Misc	Micro Paver Implementation Of The Unsurfaced Road Management System	90/04/01
TM 5-623	Pavement Maintenance Management (PAVER)	82/11/01
TM 5-624	Maintenance and Repair Of Surface Areas	77/03/31
TM 5-627	Maintenance Of Trackage	80/01/01
ETN 85-1	Surfaced Areas Material Utilization Categories (SAMUC)	89/03/10
AR 420-22	Preventive Maintenance and Self Help Program	76/07/06
AR 420-70	Buildings and Structures	76/11/17
AR 420-81	Custodial Services	74/02/04
Brochure	Wood Truss Inspection Brochure	08/05/01
Brochure	Bridge Inspection Brochure	88/10/01
TM 5-608	Contracting for Custodial Services at Army Facilities	78/04/10
TM 5-609	Military Custodial Services Manual	69/09/01
TM 5-610	Facilities Engineering: Buildings and Structures Preventive Maintenance	79/11/01
TM 5-615	Concrete and Masonry	63/11/01
TM 5-617	Maintenance & Repair Of Roofs	74/01/01
TM 5-618	Paints and Protection Coatings	81/06/01
TM 5-620	Buildings and Structures Caulking/Glazing Repairs	58/03/01
TM 5-621	Buildings and Structures Lathing and Plastering	58/08/01
TM 5-622	Maintenance Of Waterfront Facilities	88/08/01
ETN 76-6	Security/hasp Reinforcement, Outside Surfaces	76/07/06
ETN 76-8	Maintenance and Repair Control Of Mercury Contaminated For Floor	76/07/13
ETN 78-7	Life Cycle Cost Study Of Paint Existing	78/02/09
ETN 79-14	Maintenance Of Igloo Magazine Door Flashing	79/10/03
ETN 79-5	Plastic Wallcovering Materials	79/02/16
ETN 87-8	Encapsulants As An Asbestos Control Method	87/09/17
ETN 87-9	Paint Testing Kit	87/10/26
AR 420-16	Facilities Engineering Reports	87/09/13

<u>Publication No.</u>	<u>Title</u>	<u>Date</u>
CA Document	DEH Commercial Activities and Job Contracting Documents	89/11/01
DA Pam 420-8	Facilities Engineering Handbook	78/09/15
TN 420-10-03	Job Planning and Execution Guide	90/04/30
TM 5-629	Herbicide Manual	70/08/01
TM 5-630	Natural Resources - Land Management & Ground Maintenance	82/07/01
TM 5-632	Military Entomology Operators Handbook	71/12/01
AR 405-45	Inventory Of Real Property	77/03/18
AR 405-70	Space Utilization	77/02/23
DA Pam 420-10	Space Management	87/02/05
TN 405-80-1	Real Property Function Automation	90/02/28
TM 5-680/85	Operations, Maintenance & Repair Of Auxiliary Centers	47/04/01
TM 5-682	Facilities Engineering - Electrical Facilities- Safety	83/06/01
TM 5-683	Facilities Engineering - Electrical Interior	72/03/01
ETN 81-1	New OSHA Electrical Standards	81/02/05
ETN 81-10	Self-illuminating Exit Signs	81/09/18
ETN 81-3	Inspection Of Wood Poles	81/02/19
ETN 81-4	Conserving Electrical Energy	81/04/01
ETN 81-7	Air Circuit Breaker Maintenance, Suppl 1	81/06/19
ETN 81-9	Fluorescent Lamps	81/09/18
ETN 82-12	Testing Dielectric Oils for PCBs	84/01/23
TM 5-636	Kitchen Equipment Repair and Utilization	46/07/01
TM 5-642	Small Heating Systems	46/06/01
TM 5-650	Central Boiler Plants	89/10/01
TM 5-652	Steam, Hot Water & Gas Distribution System Repair and Utilization	47/04/01
TM 5-653	Steam, Hot Water & Gas Distribution System Inspection & Preventive Maintenance	46/06/01
TM 5-654	Maintenance & Operation Of Gas Systems	70/11/01
TM 5-670	Repairs of Utilities, Refrigeration, AC, Mechanical Ventilating and Evaporative Cooling	62/02/01
TM 5-671	Preventive Maintenance for Refrigeration, AC, Mechanical Ventilating and Evaporative Cooling	58/08/01
ETN 82-4	Fluidized Bed Combustion Systems	82/01/18
ETN 82-7	Capacitor Failures	82/02/25
ETN 83-2	Repairs To HVAC Systems In Older Family Housing Units	83/11/09

<u>Publication No.</u>	<u>Title</u>	<u>Date</u>
ETN 84-6	Application Of Condenser Heat Recovery To Domestic Systems	84/08/03
AR 420-15	Certification Of Utility Plant Operators	75/06/05
AR 420-43	Facility Engineering Electrical Services	87/11/27
AR 420-49	Heating, Energy Selection and Fuel Storage, Distribution and Dispensing	76/11/18
AR 420-54	Air Conditioning & Refrigeration	73/08/06
AR 420-55	Food Service and Related Equipment	76/05/18
AR 420-46	Water and Sewage	78/07/01
AR 420-47	Solid and Hazardous Waste Management	84/12/01
TM 5-634	Refuse Collection and Disposal	58/07/01
TM 5-660	Maintenance and Operations Of Water Sup Treatment & Distribution Systems	82/01/01
TM 5-662	Swimming Pool Operation & Maintenance	66/08/01
TM 5-665	Operation & Maintenance Of Domestic & Industrial Wastewater Systems	82/00/01
ETN 81	CERL Portawasher Technology Transfer	81/04/14
ETN 81-5	Minimizing Impact Of Water Supply Outages	81/06/26
ETN 82-9	Low Cost Trihalomethane Technology	82/03/12
ETN 82-10	Current Sewer System Analysis & Correction	82/04/27
ETN 83-1	Water Conservation Methods	83/05/30
ETN 84-2	Appropriate Technology for Army Waste Management: Application for Remote Sites	84/02/01
ETN 84-3	Water Savings for Low-flow Shower Heads	84/08/24
ETN 84-5	Landfill Gas Control At Military Installations	84/07/31
ETN 84-7	Use Of Synthetic-media Trickling-filter	84/07/31
ETN 86-1	Economic Analysis for Solvent Management Options	86/05/30

3. GENERAL SERVICES ADMINISTRATION

General Services Administration Publications are available from:

General Services Administration
National Forms and Publications Center (7CAFW)
Warehouse 4, Dock No. 1
4900 South Hemphill Street
Fort Worth, TX 76102

<u>Publication No.</u>	<u>Title</u>	<u>Date</u>
PBS P 6800.1C	Repair & Alteration Program Management	89/10/23
PBS P 5800.18B	Operation and Maintenance of Real Property	84/08/13
PBS P 5800.35	Energy and Water Management	83/06/10
PBS P 5810.2B	Custodial Management	81/06/22
PBS P 5850.1B	Building Maintenance Management	81/10/08

4. OTHER GOVERNMENT SOURCES FOR PUBLICATIONS

Publications Office
 Soil Conservation Service
 South Building (Room 0054)
 U. S. Department of Agriculture
 P.O. Box 2890
 Washington, DC 20013
 Telephone: (202) 447-5157

Publications Office
 Forest Service
 U. S. Department of Agriculture
 P.O. Box 96090
 Washington, DC 20090
 Telephone: (202) 447-3957

5. COMMERCIAL PUBLICATIONS

Means Facilities Maintenance Standards, R. S. Means Company, Inc., 100 Construction Plaza, Kingston, MA 02364.

The Facilities Manager's Reference, R. S. Means Company, Inc., 100 Construction Plaza, Kingston, MA 02364.

Facilities Audit Workbook, Association of Physical Plant Administrators of Universities and Colleges, 1446 Duke Street, Alexandria, VA 22314-3492.

Construction Criteria Base (CCB), National Institute of Building Sciences, 1201 L Street, N.W. Suite 400, Washington, DC 20005. This is a collection of government and industry codes, standards, guide specifications, design manuals, design standards, construction criteria, regulations, and guidelines generally applicable to facilities construction. It is available in Compact Disc-Read Only Memory (CD-ROM) form on a subscription basis.

ASHRAE Handbooks, ASHRAE, 1791 Tullie Circle, NE, Atlanta, GA 30329. This is a series of handbooks covering air conditioning and heating, refrigeration, and related equipment and

systems. Topics covered include practices, codes and standards, systems selection guides, theory, engineering data, materials, and sizing. As of this writing available titles include:

1991 HVAC Applications
1990 Refrigeration
1989 Fundamentals
1988 Equipment
Principles of HVAC
Solutions Manual

6. COST and TASK ESTIMATING GUIDES

The following are representative cost and task estimating guides that are currently available and that can be used to support facilities maintenance work order cost estimating.

6.1. Engineered Performance Standards (EPS).

The publications in the EPS series are listed below by the Naval Facilities Engineering Command publication number stock number. Engineered Performance Standards are available from:

Naval Publications and Forms Center
Attn: Code 1051
5801 Tabor Avenue
Philadelphia, PA 19120

ENGINEERED PERFORMANCE STANDARDS

<u>Publication No.</u>	<u>Title</u>	<u>Stock No.</u>
P-700.2	Planner's and Estimator's Class Exercise Workbook	0525-LP-131-0062
P-701.0	EPS Desk Guide	0525-LP-001-3280
P-702.0	EPS Carpentry Handbook	0525-LP-134-0111
P-703.0	EPS Electric, Electronic Handbook	0525-LP-137-0015
P-704.0	EPS Heating, Cooling, and Ventilating Handbook	0525-LP-139-0154
P-705.0	EPS Emergency/Service Handbook	0525-LP-140-0003
P-706.0	EPS Janitorial Handbook	0525-LP-142-0016
P-707.0	EPS Machine Shop, Machine Repair Handbook	0525-LP-144-0030
P-708.0	EPS Masonry Handbook	0525-LP-147-0012
P-709.0	EPS Moving and Rigging Handbook	0525-LP-150-0011
P-710.0	EPS Painting Handbook	0525-LP-153-0016
P-711.0	EPS Pipefitting and Plumbing Handbook	0525-LP-155-0025

ENGINEERED PERFORMANCE STANDARDS

<u>Publication No.</u>	<u>Title</u>	<u>Stock No.</u>
P-712.0	EPS Roads, Grounds, Pest Control, Refuse Collection Handbook	0525-LP-156-0016
P-713.0	EPS Sheet Metal, Structural Iron, and Welding Handbook	0525-LP-158-0006
P-714.0	EPS Trackage Handbook	0525-LP-161-0011
P-715.0	EPS Wharf Building Handbook	0525-LP-164-0011
P-716.0	EPS Unit Price Standard Handbook	0525-LP-165-0055
P-717.0	Preventive and Recurring Maintenance Handbook	0525-LP-165-0061

Engineered Performance Standards are also available in a computerized format as part of the Public Works Management Automation (PWMA), Facilities Engineering Job Estimating (FEJE) program, available for IBM AT-compatible computers from the U.S. Department of Commerce, National Technical Information Service, Springfield, VA 22161. FEJE is composed of three submodules that cover Scoping Estimates, Detailed Estimates, and Preventive Maintenance and Inspection (PM&I). The FEJE program permits addition of locally developed estimating standards to the EPS database.

6.2. R.S. Means Company, Inc.

The R. S. Means Company, Inc., 100 Construction Plaza, P.O. Box 800, Kensington, MA 02364-0800 offers a series of cost estimating guides. Most of the guides are oriented toward facilities construction and repair work; however, they can be used for estimating construction-like facilities maintenance work. The *Means Facilities Cost Data* guide contains entries for facilities maintenance. The Means guides are updated each year. Means offers over 35 publications related to cost estimating. Those of greatest interest to facilities maintenance managers include:

Means Facilities Cost Data (most comprehensive of the publications)

Means Building Cost Data

Means Repair and Remodeling Cost Data

The R. S. Means estimating standards and database are also available in computerized form from the R. S. Means company at the above address.

APPENDIX G

SAMPLE MAINTENANCE STANDARDS, INSPECTION CHECKLIST AND FORM

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APPENDIX G

SAMPLE MAINTENANCE STANDARDS, INSPECTION CHECKLIST AND FORM

1. SAMPLE INSPECTION GUIDES:

The following sample inspection guides are structured to identify unsatisfactory conditions; those conditions which do not meet the maintenance standard for the facilities component being inspected. Maintenance standards expressed in this form tell the inspector specifically what to look for with each facility component.

1.1 WALLS - INTERIOR AND CEILINGS

- a. Wood: Checking, cracking, splintered, broken; warping; sagging; support failure; rot; termite or other insect or fungus infestation; abrasion; scuff marks; mechanical damage; personal abuse.
- b. Soft Fiberboard (acoustical and insulation): Open joints; buckling; sagging; support failure; loose; missing; failure of fastenings or adhesive; abrasions; breaks; holes; stains from weather or utility leaks.
- c. Wallboard, Plasterboard, Hard-Pressed Fiberboard, and Cement-Asbestos Board: Open joints; cracking; buckling; sagging; support failure; loose; failure of nailing or adhesive; abrasion; breaks; holes; discoloration from weather or utility leaks.
- d. Plaster: Cracking, buckling, sagging, support failure; spalling, crumbling, or falling from moisture absorption; efflorescence, peeling, or flaking from moisture or sealer failure; discoloration from weather or utility leaks.
- e. Ceramic Tile: Chipped, cracked, loose, missing, holes; defective mortar joints; etched, pitted, or dull surfaces caused by use of acidulous or abrasive cleaners.
- f. Metal: Corrosion, rust, abrasions, indentations, punctures, deterioration of protective coating.

1.2 WALL COVERINGS

- a. Resilient Coverings (linoleum, vinyl plastic): Curling, loose, adhesive failure, abrasions, indentations, punctures, tears; etched, pitted or dull surfaces caused by the use of acidulous or abrasive cleaners.
- b. Canvas and Paper: Breaks, wrinkling, fading adhesive failure.

- c. Weather or Utilities Leaks: Damage to wall coverings, evidence of mechanical damage or personal abuse.

1.3 DOORS AND WINDOWS

- a. Wood Sash, Doors, and Trim: Splitting, rotting, cracking, loose, poor fit, binding, missing, loose or missing caulking, lack of weather-tightness.
- b. Metal Sash and Doors: Rust, corrosion, warping, binding, poor fit, lack of weather-tightness.
- c. Storm Sash: Binding, jamming, poor fit of frames; metal parts for rust and corrosion; wood parts for rotting and other damage.
- d. Screens: Loose, broken, or missing hardware; binding, jamming, poor fit of frames; metal parts for rust, corrosion, holes in fabric; wood parts for rotting, stain, other damage.
- e. Shutters: Splitting, rotting, cracking, loose, missing, misalignment, or little or no free motion as required.
- f. Hardware: Loose, missing, broken parts; binding, misalignment, improper installation or adjustment, lack of lubrication; corrosion, abrasion, loss of finish coating.
- g. Glass: Missing or broken panes; disintegration of putty.
- h. Trim: Looseness, scratches, indentations, mechanical damage, personal abuse.
- i. Venetian Blinds Window Shades: Insecure or broken fasteners; poor operation; frayed or broken cords or tapes; broken or damaged slats; worn or torn material.

2. SAMPLE FIVE-LEVEL CONDITION ASSESSMENT GUIDES:

The following two condition assessment guides are samples of the type of guide that can be used in conjunction with the inspection guides as the basis for conducting a comprehensive assessment of facilities maintenance condition and will assist in qualifying the maintenance condition. The guides are structured to provide assessment in one of five levels for each item assessed.

2.1 WINDOWS, DOORS, LOUVERS, AND VENTS

Code Narrative Rating

- 5 - EXCELLENT CONDITION: No work required.
- 4 - GOOD CONDITION: Only preventive maintenance required. Minor recaulking required. Sticking, squeaking, or minor misalignment. Normal wear and tear on weather stripping, thresholds, and screens.
- 3 - FAIR CONDITION: Minor repairs required. Failure to close tightly. Restricted movement. Cracked panes panels, or slats. Recaulking required. Minor corrosion, decay, insect damage, or deformation.
- 2 - POOR CONDITION: Significant repairs required. Broken or missing panes, panels, or slats. Broken hardware/closer/operator. Broken frame. Significant corrosion, decay, insect damage, or deformation.
- 1 - BAD CONDITION: Replacement required.

2.2 FINISHES, INTERIOR WALLS

Code Narrative Rating

- 5 - EXCELLENT CONDITION: No work required.
- 4 - GOOD CONDITION: Only preventive maintenance required. Slight evidence of marring, discoloration, dirt accumulation, fading, cracking, or staining.
- 3 - FAIR CONDITION: Minor repairs required. Moderate amount of marring, discoloration, dirt accumulation, fading, cracking, peeling, tearing, staining, or grout failure. Normal wear and tear visually noticeable. Mismatched tile.
- 2 - POOR CONDITION: Significant repairs required. Significant size/extent of marring, discoloration, dirt accumulation, fading, cracking, peeling, tearing, staining, or grout failure. Broken elements. Wear and tear excessive.
- 1 - BAD CONDITION: Replacement required.

3. SAMPLE CONDITION INSPECTION FORM:

3.1 CONDITION INSPECTION FORM:

Figure G-1 is a sample form that can be used as an aid in conducting and documenting facilities condition assessment or control inspections. The form, or an equivalent, should be preprinted by the CMMS with scheduling, item identification information, and maintenance standards and inspection guides.

3.2 INSPECTION FORM DATA ELEMENTS:

The following data elements are shown on the sample form:

<u>Data element:</u>	<u>Description:</u>
1. Inspection No.:	A sequential number identifying the inspection that can be used for tracking and reference. Bar code maybe used to speed data entry.
2. Due Date:	Date inspection is due in the case of inspections that are scheduled as part of the maintenance management system.
3. Facility No.:	The building or facility number.
4. Last Insp.:	The date of the last regular inspection of the item to be inspected.
5. Location:	The location of the item being inspected.
6. Nomenclature:	The name and short description of the item being inspected.
7. Inventory No.:	The identifying number for the facility or facility related equipment item being inspected. This is the identifying number as contained in the facilities maintenance management inventory system. Bar code may be used to speed data entry.
8. Guide No.:	The identifier for the inspection guide and/or check list used.
9. Inspector:	Name and signature of the person performing the inspection.
10. Date:	Date of the inspection.
11. Condition Code:	A short code for the overall condition assessment of the item being inspected.
12. Cost Est:	A summary scoping estimate of the cost to correct all maintenance deficiencies discovered in the inspection. This is the total of date element 15 entries.
13. Item No.:	A number used to identify each finding in the report.
14. Findings:	A narrative summary of deficiencies discovered, including recommended corrective actions and other descriptive data. The information provided here should be sufficient for development of a scoping estimate.
15. Cond:	Condition, the condition code assigned to this finding if applicable. Data element 11 is an summary of the individual item codes.

SAMPLE CONTROL INSPECTION FORM				Inspection No: (1)	
Due Date: (2)		Facility No.: (3)		Last Insp.: (4)	
				Location: (5)	
Nomenclature (6)					
Inventory No: (7)		Guide No. (8)		Inspector: (9)	
		Date: (10)			
Condition Code: (11)		Cost: (12)			

16. Cost: This is a scoping estimate of the cost to correct the finding.
17. Supplement: This area may incorporate by reference data such as photographs, predictive test results, video images, and other tests. It should cite the type, source, and location of the data. An interpretation of the data should be summarized in Findings section.
18. Action: Summary statement of actions taken with regard to the inspection results. More than one entry is possible and may take the form of a combination of actions, such as Trouble Calls, Repair work orders, and inclusion in the backlog of deferred facilities maintenance. Action entries are keyed to findings by the item number.
19. Reviewed By: The maintenance management official reviewing and approving the inspection report, including actions.
20. Date: The date the inspection report is approved.

3.3 USE OF THE INSPECTION FORM:

- a. The basic form should be prepared by the CMMS, based on the control inspection schedule. The CMMS should provide data elements 1 through 8. The form would be prepared along with associated inspection guides and provided to the inspectors sufficiently in advance of the due date to permit review of past inspection results and necessary coordination of clearances, outages, and access.
- b. The supervisor of the inspection section assigns an inspector, data element 9.
- c. The inspector uses the form to document the inspection results, including preparation of scoping estimates for Repair where required, completing data elements 10 through 17. Continuation sheets should be used for data elements 13 through 18 as required.
- d. When the inspection is completed the form is reviewed by the maintenance planning section to determine necessary maintenance actions, which are entered as data element 18. The inspection is reviewed, approved (data elements 19 and 20) and then the inspection findings and resulting actions are entered in the facilities maintenance database.

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APP

PREDICTIVE TESTING and

TECHNIQUE

PURPOSE

APPLICATION

EFFECT

VIBRATION ANALYSIS

Vibration analysis can detect, identify, and isolate specific component degradation and the method by which it is failing prior to actual failure or serious damage.

Periodic vibration data is collected and subjected to trend analysis on microprocessor-based systems with smart programs by trained personnel.

Rotating machinery bearings, shafts, gears, pulleys, blowers, belts, couplings, etc.

Reciprocating equipment.

Frequency analysis of induction motors to diagnose for broken motor bars, cracked end rings, high resistance joints, winding faults, casting porosity, air-gap eccentricities.

Can isolate failing component, failure mode, and predict time to failure.

OIL ANALYSIS

Lubricating Oil Properties Analysis

Determination of the condition of lubricating oil by testing for viscosity, contaminants, dilution, solids content, oxidation, etc.

Engines, compressors, turbines, transmissions, gear boxes, etc.

Determine cost-effective interval for changing oil and determine if oil meets requirements.

Wear Particle Analysis/Magnetic Particle Inspection

An analysis technique that determines the condition of a machine or machine components through examining particles contained in a lubricating oil sample. Wear particles are separated magnetically and subjected to ferrographic and microscopic analysis.

Can isolate a failing component, the mode of failure, and the estimated time to failure.

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ENDIX II

1 MAINTENANCE TECHNIQUES

	<u>EQUIP. REQUIRED</u>	<u>OPERATORS</u>	<u>TRAINING AVAILABLE</u>	<u>COST (1990)</u>
compo- nd pre-	Vibration analysis systems are composed of microprocessor data collectors, vibration transducers, and host PC with software for analyzing trends, establishing alarm points, and assisting in diagnostics.	Requires personnel with ability to understand basics of vibration theory and basic knowledge of machinery and failure modes.	Training available through equipment vendors and Vibration Institute.	\$30,000 to \$70,000 for system, software, and primary training.
ive in- l. De- ube re-	Extensive and expensive laboratory equipment required; thus, in-plant analysis is not justified.	Equipment operators or maintenance craft personnel trained to take samples.	Training plant operators to take accurate samples.	\$10 to \$45 per sample for analysis and report.
compo- failure, ime to		Analysis is performed by off-site trained laboratory personnel.		72-hour turnaround, telephone report when problem critical. Modem link to customer vibration analysis PC and program available.

NDIX H

MAINTENANCE TECHNIQUES

	<u>EQUIP. REQUIRED</u>	<u>OPERATORS</u>	<u>TRAINING AVAILABLE</u>	<u>COST (1990)</u>
loss & from a aks or ories. perature	Equipment ranges from relatively inexpensive black-and-white scanners to full-color imaging computer-based systems that can store, recall, and print thermal images.	Training is required to obtain accurate and repeatable thermal data and to interpret the data. Can be operated by electrical/mechanical technicians and/or engineers.	Training available through infrared imaging system manufacturers and vendors.	Point-of-use black-and-white scanners are less than \$1,000. Full color micro-processor systems with data storage and print capability range up to \$70,000. Rental of full system is approximately \$1200/week. Subcontractor services are approximately \$750/day.
on be- pletely. d insu- le, or can be months	Portable surge comparison tester cabinet, with accessories available for testing DC armatures and photographing decay patterns for records.	Minimal training is required for use by electricians, electrical technicians, and engineers.	Manufacturers provide seminars to teach testing techniques.	Equipment cost varies by capacity, from \$8,000 for a 3KV unit to \$15,000 for a 24KV unit.
ion of stricted break- sure or easure on in Will bearing	Ultrasonic monitoring scanner for airborne sound or ultrasonic detector for contact mode through metal rod.	Maintenance technicians and engineers.	Minimal training required.	Scanners and accessories range from less than \$1,000 to about \$8,000.

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APPE

PREDICTIVE TESTING and

TECHNIQUE

PURPOSE

APPLICATION

EFFECT

INFRARED SCANNING & IMAGING

Detects and determines temperature differences by scanning infrared emissions of complete machines, process systems, equipment, and buildings.

Electrical apparatus.
Bldg. walls and roofs.
Insulation.
Remote mechanical equip.
Steam traps.
Refractories.
Bearings.

Locates hot spots.
Locates heat gain/loss roof leaks.
Accurately measures distance.
Detects steam trap malfunction.
Locates falling refract.
Locates overtemp areas on machinery.

SURGE COMPARISON TESTING

Detects turn and phase insulation weakness by applying a pulse simultaneously to two phases of an induction motor. Two wave patterns are produced on a screen. Turn-to-turn or phase-to-phase weaknesses are readily identifiable.

Induction motors, synchronous motors or generators, DC fields, and armatures. Range application is 3 HP to above 8,000 HP.

Locates weak insulation before motor fails completely. Can find faulty ground in motors, cables, switchgear. Faults detected up to 4 weeks prior to failure.

ULTRASONIC MONITORING

Monitor high frequency sound generated by plant machinery and systems. Ultrasonic frequencies range between 20,000 and 100,000 kilohertz.

Piping and process systems, steam traps, refrigeration systems, rotating machinery.

Leak detection, locate turbulent flow or reverse flow, and voltage drop. Finds gas pressure vacuum leaks. Can monitor corrosion and erosion piping and vessels. assist in locating failures.

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APPENDIX H

Field MAINTENANCE TECHNIQUES

	<u>EQUIP. REQUIRED</u>	<u>OPERATORS</u>	<u>TRAINING AVAILABLE</u>	<u>COST (1990)</u>
corrosion. port dam-	Eddy current probe, multi-frequency signal generator, CRT, oscilloscope, strip-chart recorder.	Requires skills obtained from extensive training and experience. Because of skill required and infrequent necessary inspections, subcontracting to specialty firms is economically advisable.		Equipment cost is \$28,000 to \$150,000.
inspected special collects s. The clean and ected by . Devel- lights are once visi-	Equipment required includes dyes, developers, ultraviolet lights, and possibly microscopes for close examination of parts.	This is typically contracted out to laboratory services.		Generally low cost.
ily detect				
of soil near the insulation , can be nowledge he losses Requires ing loca-	Temperature probes, analysis software, and equipment to determine location of piping systems.	Center personnel can apply this system after receipt of training, although it is often contracted.		Cost for contract services ranges from \$1500 to \$2000 per day with \$5000 to \$6000 for the first day.

2. Cost data reflects a range of typical costs expressed in 1990 dollars. This is subject to great variance depending on scope and field conditions as well as changes in technology over time. Local costs should be researched when developing estimates for a specific application.

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AP

PREDICTIVE TESTING at

TECHNIQUE

PURPOSE

APPLICATION

EFFECT

EDDY CURRENT TESTING

Detection of flaws or tube failure on non-ferrous heat exchanger equipment.

A probe inserted in the tube sets up an alternating current-induced magnetic field. A flaw-caused disturbance in the eddy currents' magnetic fields is detected, amplified, and displayed on a CRT or strip-chart recorder.

Boilers.
Heat exchangers.
A/C units.
Feedwater heaters.
Condensers.
Thermal oxidizers.

Limited to non-ferrous material.

Requires unit to be down for testing.

Detects pitting, corrosion, freeze damage, surface age, and cracks.

LIQUID PENETRANTS

Liquid penetrants highlight surface defects such as cracks, pits, scratches, and depressions where a dye can collect.

Used for inspection of piping welds, boiler tubes, valves, generator retaining rings, and other areas of high stress.

The surface being inspected is coated with a penetrant dye which penetrates surface defects. The surface is wiped clean and the defect is detected by the presence of the dye. Special developers and special dyes are often used to enhance the visibility of the dyes.

This system can be used to detect surface defects.

DEEP PROBE TEMPERATURE ANALYSIS

Detects energy loss and leakage by examination of temperature of surrounding soils.

Can be used to quantify energy loss and cost of losses.

Used on direct-buried pipes carrying steam or hot water.

By measurement of temperature profile of pipe, failure of systems and leaks can be detected. With knowledge of soil properties, temperature can be estimated. Knowledge of pipe condition.

Notes:

1. Numerous other non-destructive testing and inspection techniques are available to detect concealed defects in systems or equipment. See the tables that follow this section.

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PREDICTIVE TESTING TECHNIQUES

The following pages are several matrices of Predictive Testing & Inspection techniques with examples of their applications to utility systems. A brief description is given below for each technology not introduced above.

Ultrasound. Ultrasound involves the use of special sensing devices to detect response to vibrations applied to the item being inspected. It can be applied in several modes including pulse-echo, through-transmission, resonance, and angled-beam. Operation is based on the principle that fault conditions will result in abnormal or changes to sound transmission and reflection characteristics.

Acoustic Emissions. Acoustic emissions involves use of special equipment to listen for sounds made by fault or failure conditions such as leaks in pressurized or vacuum systems. It corresponds to the ultrasonic monitoring presented on page H-2.

Sulfur Hexafluoride. Sulfur Hexafluoride (SF_6) methods are used to find leaks in systems. The system is filled with SF_6 gas and then special detectors are used sense SF_6 concentrations above normal which indicates the location of a leak.

Radiography. Radiography covers X-ray (or gamma or neutron) beams used to penetrate the item being tested to determine thickness and density and to reveal voids or flaws.

Magnetic Flux. Magnetic flux test methods examine the flux leakage patterns surrounding magnetized ferromagnetic material. Flaws are revealed by abnormal magnetic patterns.

Insulating Oil Test. Insulating oil tests examine the oil's properties such as dielectric strength, power factor, contaminant levels, and acidity.

Diagnostic Monitoring. Diagnostic monitoring refers to real-time, on-line monitoring of system conditions and operating parameters, including use of many of the techniques listed here, to provide alarms or automatic operation of control systems.

Fiber Optics/Borescopes. Fiber optics and borescopes are visual inspection methods that use lenses and/or and fiber optic light guides to permit visual examination of hard to reach locations.

Replication. Replication methods involve making a plastic foil casting of a portion of an item, then subjecting the casting to microscopic examination. Defects such as stress cracks will show up in the casting.

Electromagnetic Pipe Location. Electromagnetic pipe location is used to locate and map underground systems. It involves tracing a system by directly applying or inducing a signal in the system and then using an induction pick-up to detect the signal.

Radar Mapping. Radar Mapping is used to locate and map underground systems. It involves using ground penetrating radar to detect buried items.

Holographic Interferometry. Holograph photography is used to record deformations caused by stress or vibration. The degree of deformation can be determined by interference patterns that arise when compared to normal conditions.

Boring. Boring is an inspection method that involves boring holes into the tested item, such as a utility pole, and determining the condition by examining the shavings.

Holiday & Fault Location. Holiday and fault location is used to find breaks in the insulation of piping and cable systems by detecting electrical signal leakage above the pipe or cable.

Electrical equipment tests. Electrical equipment tests cover a variety of alternating and direct current tests of equipment such as insulation resistance, power factor, hi-potential, and leakage.

The book, *An Introduction to Predictive Maintenance* by R. Keith Mobley, Van Nostrand Reinhold, New York, 1990, provides a good introduction to the application of Predictive Testing & Inspection techniques to a facilities maintenance program, including a discussion of the theory underlying the various techniques available.

INSPECTION TECHNOLOGIES

APPLICATION

UTILITY SYSTEMS: COMPRESSED AIR

	INFRARED	ULTRASOUND	ACOUSTIC EMISSIONS	SULFUR HEXAFLUORIDE	RADIOGRAPHY	EDDY CURRENT	LIQUID PENETRANT	MAGNETIC FLUX	INSULATING OIL TEST	VIBRATION SIGNATURE	DEEP PROBE TEMPERATURE	DIAGNOSTIC MONITORING	FIBEROPTICS/BORESCOPIES	REPLICATION	ELECTROMAG. PIPE LOCATE	RADAR MAPPING	HOLOGRAPHIC INTER.	BORING	HOLIDAY & FAULT LOCAT.	ELECT. EQUIP. TESTS
Controls-Electric	X														X				X	
Controls-Thermal	X																			
Electric Drive	X	X								X		X								
Steam Drive	X									X		X								
Motor Drive	X									X		X								
Compressor										X		X								
-Vibrations			X							X		X								
-Hot Stuffing Box	X											X								
-Hot Bearings, Belts, Gears	X									X		X								
-Valves and Seats	X		X		X		X	X				X		X						
-Pistons, Rings, Cyls., Rods	X	X	X		X	X	X	X		X		X		X						
-Rotor, Stator Wear	X	X	X		X	X	X	X		X		X		X						
Intercoolers/Aftercoolers	X	X	X		X	X	X	X				X								
Traps																X				
Receiving Tanks		X	X		X			X				X			X	X	X		X	
Drip Legs					X			X							X	X				
Distribution, Service Lines		X	X		X			X					X			X	X		X	
Valves		X	X		X		X	X						X	X	X	X			
Fittings		X	X		X		X	X					X	X	X	X				
Welds		X	X		X		X	X					X	X						
Cathodic Protection															X				X	
Conduits				X											X	X				
Pipe Supports/Anchors																				

Source: Draft report UTILITIES INSPECTION TECHNOLOGIES, Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1990

INSPECTION TECHNOLOGIES

APPLICATION

UTILITY SYSTEMS: ELECTRICAL

	INFRARED	ULTRASOUND	ACOUSTIC EMISSIONS	SULFUR HEXAFLUORIDE	RADIOGRAPHY	EDDY CURRENT	LIQUID PENETRANT	MAGNETIC FLUX	INSULATING OIL TEST	VIBRATION SIGNATURE	DEEP PROBE TEMPERATURE	DIAGNOSTIC MONITORING	FIBEROPTICS/BORESCOPES	REPLICATION	ELECTROMAG. PIPE LOCATE	RADAR MAPPING	HOLOGRAPHIC INTER.	BORING	HOLIDAY & FAULT LOCAT.	ELECT. EQUIP. TESTS
Capacitors	X								X											
Insulating Liquid	X		X						X											
Motor Windings	X																			X
Motor Connections	X									X										
Bearings, Belts, Gears	X									X		X								
Generator Retaining Rings							X	X												
Generator Windings			X																	X
Generator Brushes		X			X	X		X		X			X							
Rotor, Stator																				
Oil Insulated Transformers		X	X						X											X
Conductors	X					X									X	X			X	X
Suspension Insulators	X																			X
Steel Pole, Welds		X			X			X							X					X
Gas Insulated (SF ₆) Equip.				X																X
Switchgear and Breakers	X								X											X
Busses, Connections	X																			X
Post Insulators	X																			X
Transformer Bushings	X																			
Conductors	X		X													X			X	
Distribution Transformers	X								X											
Suspension Insulators	X																			X
Pin and Cap Insulators	X																			X
Wood Poles		X			X													X		
Power Lines and Splices	X														X	X		X	X	

Source: Draft report UTILITIES INSPECTION TECHNOLOGIES, Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1990

INSPECTION TECHNOLOGIES

APPLICATION

UTILITY SYSTEMS: NATURAL GAS

	INFRARED	ULTRASOUND	ACOUSTIC EMISSIONS	SULFUR HEXAFLUORIDE	RADIOGRAPHY	EDDY CURRENT	LIQUID PENETRANT	MAGNETIC FLUX	INSULATING OIL TEST	VIBRATION SIGNATURE	DEEP PROBE TEMPERATURE	DIAGNOSTIC MONITORING	FIBEROPTICS/BORESCOPES	REPLICATION	ELECTROMAG. PIPE LOCATE	RADAR MAPPING	HOLOGRAPHIC INTER.	BORING	HOLIDAY & FAULT LOCAT.	ELECT. EQUIP. TESTS
Feeder, Distr., Supply Mains			X	X		X				X				X	X	X	X	X	X	
Drip Legs			X			X														
Valves			X	X		X		X		X					X	X	X			
Pipe Fittings			X	X		X		X		X				X	X	X			X	
Welds			X	X		X		X		X				X		X	X		X	
Cathodic protection															X	X	X		X	

Source: Draft report UTILITIES INSPECTION TECHNOLOGIES, Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1990

INSPECTION TECHNOLOGIES

APPLICATION

UTILITY SYSTEMS: STEAM

	INFRARED	ULTRASOUND	ACOUSTIC EMISSIONS	SULFUR HEXAFLUORIDE	RADIOGRAPHY	EDDY CURRENT	LIQUID PENETRANT	MAGNETIC FLUX	INSULATING OIL TEST	VIBRATION SIGNATURE	DEEP PROBE TEMPERATURE	DIAGNOSTIC MONITORING	FIBEROPTICS/BORESCOPIES	REPLICATION	ELECTROMAG. PIPE LOCATE	RADAR MAPPING	HOLOGRAPHIC INTER.	BORING	HOLIDAY & FAULT LOCAT.	ELECT. EQUIP. TESTS
Boiler Tank	X	X	X		X	X		X				X	X				X			
-Tubes/Headers	X	X	X		X	X	X	X				X	X	X			X			
-Steam Drum		X	X		X	X		X				X	X	X			X			
-Superheaters/Reheaters		X	X		X	X	X	X				X	X	X			X			
-Economizers		X	X		X	X	X	X				X	X	X			X			
-Turbines		X	X			X		X		X		X	X	X						
Forced/Induced Draft Fans			X							X		X								
Stack	X									X		X								
Feedwater Storage Tanks		X	X		X	X		X				X					X			
Pumps			X					X		X		X		X						
-Gears, Belts, Bearings	X									X										
Pipes	X	X	X		X			X		X	X	X	X		X	X	X		X	
Valves	X		X		X		X	X			X		X	X	X	X				
Fittings, Connections, Welds	X	X	X		X		X	X			X		X	X	X	X			X	
Condensors	X									X		X								
Evaporators	X									X		X								
Conduits											X				X	X				
Traps	X			X				X				X								
Cathodic Protection															X	X			X	
Seals			X								X									
Insulation	X	X								X										
Expansion Tank		X	X		X	X		X				X					X			
Electrical Equipment	X				X	X		X				X								
Drip Legs																				

Source: Draft report UTILITIES INSPECTION TECHNOLOGIES, Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1990

INSPECTION TECHNOLOGIES

APPLICATION

UTILITY SYSTEMS: HOT WATER

	INFRARED	ULTRASOUND	ACOUSTIC EMISSIONS	SULFUR HEXAFLUORIDE	RADIOGRAPHY	EDDY CURRENT	LIQUID PENETRANT	MAGNETIC FLUX	INSULATING OIL TEST	VIBRATION SIGNATURE	DEEP PROBE TEMPERATURE	DIAGNOSTIC MONITORING	FIBEROPTICS/BORESCOPIES	REPLICATION	ELECTROMAG. PIPE LOCATE	RADAR MAPPING	HOLOGRAPHIC INTER.	BORING	HOLIDAY & FAULT LOCAT.	ELECT. EQUIP. TESTS
Boiler-Tank	X	X	X		X	X		X				X	X				X			
-Tubes/Headers	X	X	X		X	X	X	X				X	X	X			X			
Controls-Electrical	X																			
Conduits				X							X									
Feeder/Distr./Svc. Mains	X	X	X		X	X		X			X	X	X	X	X	X	X		X	
Meters		X																		
Valves	X		X		X		X	X			X			X	X					
Measurement Controllers		X																		
Fittings/Connections	X		X		X	X	X	X			X			X	X	X	X		X	
Cathodic protection																			X	
Pumps			X					X		X		X								X
Insulation	X										X									
Expansion Tanks		X	X		X	X		X				X					X			
Heat Exchangers	X	X	X		X	X	X	X				X	X	X	X		X			
Fans			X			X				X		X								X
Driving Equipment	X									X		X								X
Stack	X											X								

Source: Draft report UTILITIES INSPECTION TECHNOLOGIES, Naval Energy and Environmental Support Activity, Port Hueneme, CA, June 1990

APPENDIX I
ENERGY CONSERVATION
CHECKLIST

BUILDINGS

Reduce Operating Hours for:

- Space Heating and Cooling Systems
- Ventilation Systems
- Water Heating Systems
- Lighting Systems
- Escalators and Elevators
- Equipment and Machines

Adjust Space Temperature and Humidity Setpoints:

- Lower Heating and Raise Cooling Temperature Setpoints
- Lower Humidification and Raise Dehumidification Setpoints
- Adjust Setpoints Back When the Building Is Not Occupied

Reduce Heat Conduction Through Ceilings and Roofs:

- Insulate Ceilings and Roofs
- Install Vapor Barriers in Ceilings and Roofs

Reduce Solar Heat Gain Through Roofs:

- Install Reflective Roof Surfaces

Reduce Heat Conduction Through Walls:

- Insulate Walls
- Install Vapor Barriers in Walls

Reduce Heat Conduction Through Floors:

- Insulate Floors

Reduce Heat Conduction and Long-Wave Radiation Through Glazing Areas:

- Install Storm Windows and Multiple-Glazed Windows
- Install Operable Windows

Control Solar Heat Gain Through Glazing Areas:

- Install Exterior Shading
- Install Interior Shading
- Use Tinted or Reflective Glazing or Films
- Install Air-Flow Windows

Reduce Infiltration:

- Seal Vertical Shafts and Stairways
- Caulk and Weatherstrip Doors and Windows
- Install Revolving Doors or Construct Vestibules

HEATING, VENTILATION, AND AIR-CONDITIONING (HVAC) SYSTEMS

Reduce Ventilation:

- Reduce Ventilation Rates
- Reduce the Generation of Indoor Pollutants
- Install Air-to-Air Heat Exchangers
- Install Air Cleaners
- Install Local Ventilation Systems

Improve Chiller Efficiency:

- Clean Evaporator and Condenser Surfaces of Fouling
- Raise Evaporator or Lower Condenser Water Temperature
- Isolate Off-Line Chillers and Cooling Towers
- Install Evaporatively Cooled or Water-Cooled Condensers

Improve Boiler or Furnace Efficiency:

- Clean Boiler Surfaces of Fouling
- Check Flue for Improper Draft
- Check for Air Leaks
- Install Flue Gas Analyzers for Boilers
- Preheat Combustion Air, Feed Water, or Fuel Oil with Reclaimed Waste Heat
- Isolate Off-Line Boilers

- Install Automatic Vent Dampers
- Install Automatic Boiler Blow-Down Control
- Install Pulse or Condensing Boilers/Furnaces
- Install Air-Atomizing Burners (for Oil-Fired Systems)
- Install Low-Excess-Air Burners (for Oil-Fired Systems)
- Install Modular Units

Improve Air-Conditioner or Heat Pump Efficiency:

- Clean Air Filters
- Install Add-On Heat Pumps
- Install Ground or Ground-Water Source Heat Pumps

Reduce Energy Used for Tempering Supply Air:

- Install Variable Air Volume Systems
- Reset Supply Air Temperatures
- Reset Hot/Chilled Water Temperatures

Use Energy-Efficient Cooling Systems:

- Install Economizer Cooling Systems
- Install Evaporative Cooling Systems
- Install Desiccant Cooling Systems
- Install Cooling Tower Cooling Systems
- Install Roof-Spray Cooling Systems
- Create Air Movement with Fans
- Exhaust Hot Air from Attics

HVAC DISTRIBUTION SYSTEMS

Reduce Distribution System Energy Losses:

- Repair Ducting and Piping Leaks
- Maintain Steam Traps
- Insulate Ducts
- Insulate HVAC System Pipes

Reduce System Resistance:

- Clean Air Filters in Ducts
- Remove Scale from Water and Steam Pipes
- Rebalance Piping Systems

- Rebalance Ducting Systems
- Design Ducting Systems to Reduce Flow Resistance
- Install Booster Pumps

WATER HEATING SYSTEMS

Reduce Hot Water Loads:

- Reduce Hot Water Consumption
- Lower Hot Water Temperatures
- Preheat Feedwater With Reclaimed Waste Water

Reduce Peak Power Demand:

- Use Load-Shedding
- Install a Cogeneration System

MISCELLANEOUS

Use Energy Management and Control System Installations:

- Temperature Setup/Setback Control System
- Time-of-Day Control System
- Duty-Cycling Control System
- Supply Air Temperature Reset Control System
- Hot/Chilled Water Supply Temperature Reset Control System
- Ventilation Purging Control System
- Economizer Cooling Control System
- Demand-Limiting Control System

Use Heat Reclaim Systems:

- Install Double-Bundle Chillers
- Reclaim Heat from Boiler Blowdown
- Reclaim Incinerator Heat
- Reclaim Heat from Combustion System Flue
- Install Water-Loop Heat Pump Systems
- Reclaim Heat from Prime Movers
- Install Piggyback Absorption Systems
- Recover Heat from Light Systems
- Reclaim Heat from Refrigerator Hot Gas

- Reclaim Heat from Steam Condensate
- Reclaim Heat from Waste Water

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